Ocular Trauma

Series Editor: Hua Yan

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Editor

Atlas of Ocular Trauma

Springer

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Series Editor

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Ocular trauma can be a serious threat to vision, especially if not medically intervened appropriately and in a timely fashion. Immediate and accurate diagnosis and effective treatment is the key to save the eyes and visual function, as well as a great challenge to ophthalmologists, especially emergency doctors. This book series is designed to help the doctors and clinical practitioners have a thorough understanding of ophthalmic emergencies and a mastery of every details of ocular trauma. To do the best, it is required that the ER doctors have solid theoretical knowledge about the anatomy of the eye and basic skills in ophthalmic operations. For that reason, "Anatomy and examination of ocular trauma" is believed to be necessary and fundamental for this book series. Beyond this, familiarity with the emergency room and efficient protocol will be helpful for the doctors to give treatment in the first time, and it will also be an important part of this book series. Almost all the aspects and details of ocular trauma will be covered in this book series, including mechanical and non-mechanical ocular trauma. Special topics of complicated situations, such as ciliary body impairment, will also be introduced in this book series. Hopefully the readers will enjoy it and find it helpful for them to provide better care to the patients and save vision.

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Preface

I am really pleased to accept the offer and to take up the challenge of inviting all prior authors to edit all these chapters to address basic knowledge of ocular tauma and present ouclar trauma cases with abundant figures. A thorough accumulation of case presentations of ocular trauma is a prerequisite for proper analysis and intervention of ocular trauma in the clinic, which provide better interpretation of long-term outcomes of eye injuries. This book aims to provide the most thorough knowledge of ocular trauma related to mechanical injury and chemical or thermal injury to clinical practitioners, such as the medical students, residents, fellows, and ophthalmologists, to help them make the most appropriate decision on the management of patients who have suffered from such ocular conditions.

This book overall has been divided into two parts encompassing the basic knowledge of ocular trauma and the detailed case presentations based on the ocular anatomy, including conjunctival injury, corneal injury, iris and ciliary body injury, lens injury, vitreous hemorrhage, retinal and choroidal injury, eye lid injury, lacrimal apparatus injury, orbital injury, traumatic optic neuropathy, ocular perforating injury, rupture eye, ocular chemical burn, and ocular thermal and radiation burns. Part I demonstrates the epidemiology of ocular trauma and the classification and evaluation system of ocular trauma with its current status and how it works. In Part II, for each chapter, detailed clinical workup, clinical presentations and signs, and pictures or illustrative figures are provided. Additionally, the pearls section, which conclude the chapters, help emphasize the most definite point in each chapter. Hopefully, this book may help the clinical practitioners to be fully prepared for any challenge of ocular traumatic cases.

Tianjin, China Hua Yan

Contents

1 Introduction

Yuanyuan Liu and Hua Yan

Abstract

Ocular trauma (OT) is an important preventable cause of blindness and visual impairment in the world, with approximately 55 million occurred annually and high risk to permanent visual impairment with long-term disabilities. In addition, different subtypes of ocular trauma resulted from various sources may result in different complications, in which surgery might be required and greater vision loss caused. Hence it is of great significance to make a consensus on the basic concept of ocular trauma, aiming to have a better analysis and efficient medical treatment for ocular trauma in the clinic. This chapter is dedicated to give a comprehensive introduction about terminology, epidemiology, uniformed classification, source, and score of ocular trauma.

Keywords

Ocular trauma · BETT · OTS

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1.1 Terminology of Ocular Trauma

Trauma including physical injury or chemical erosion can cause a wide spectrum of lesions of globe and adnexa, resulting in structural or functional abnormality to some extent. Unlike to the other parts covering with clothes, the eyes are more vulnerable to be injured due to no protection or spectacles. Although no accurate data about incidence of ocular trauma or blindness caused by ocular trauma worldwide, half a million of blindness induced by ocular trauma were assumed by conservative estimates documented by WHO [1]. By now, ocular trauma has been the main preventable cause of blindness and visual impairment worldwide. Hence, it is worthwhile to make the strengthening of preventive measures in terms of need for medical care, loss of income, and cost of rehabilitation services on ocular trauma victims.

1.2 Epidemiology

1.2.1 Annual Incidence of Ocular Trauma

The true annual incidence of ocular trauma had no reliable data supported yet, since there was no comprehensive record system establishment.

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However, attempts had been made to count the annual rate of ocular trauma in hospitalized patients, which was varied from different regions. In the United States, the overall estimated rate of ocular trauma ranged from 8.2 to 13.0 per 1000 population from 1992 through 2001, i.e., approximately two million ocular traumas occurred [2]. The annual incidence rate of hospitalization for eye injuries is 8.1 in Scotland and 12.6 in Singapore [3, 4]. In addition, the rate was a little higher, 21%, in Australians aged 40 years and older living in Victoria [5]. According to Wang's analysis based on overall reports of hospitalized ocular trauma cases, ocular trauma accounted for 1/3 eye disease hospitalization in China [6]. Presumably, there were 55 million ocular traumas that occurred annually, with 19 million resulting in major vison loss and blindness worldwide [7].

1.2.2 Risky Population

Males are usually more prone to ocular trauma than females, which is more clear in children, where four more times accident-related ocular trauma occurred in boys than girls [8]. The male predominance remained higher in reports from different areas, which is approximately 80% [9]. Furthermore, the age factor is quite significant to consider for occurrence and visual prognosis of ocular trauma. There is a decreasing risk by age of ocular trauma, and most were young ranging from 30 to 40 years old [9]. It has been demonstrated that there is 80% higher risk of sustaining ocular trauma for the individual who is 10 years younger, when two persons are compared. In addition, low socioeconomic status, poor education, and engaging in labor-intensive occupations, like farmers or workers, are other confounding variables involved in ocular trauma [10, 11].

1.2.3 The Occasion and Source of Ocular Trauma

Workplace is the most traditional occasion for occurrence of ocular trauma as reported. In the Singapore Chinese Eye Study, more than 70% of ocular trauma take place in those settings, such as workshop [12]. Besides, home, streets, or highways are also common sites for ocular trauma [13].

As reported, the two most common injury sources are foreign body and being struck by blunt object. The typical blunt objects responsible for ocular trauma in China and the United States are fists or feet, rocks, sticks, wood branches, glass bottles, professional instruments, and those by accidents [14], while sharp objects including nails, broken glass objects, metal slides, or pencils are common in these areas. Explosion from chemicals or fireworks, wherever it is legal to play, is also a major source for ocular trauma. Aside from the above sources, ocular trauma caused by sports or recreative activity appears to gain more, such as basketball, volleyball, or baseball [15]. In addition, chemicals, both acid and alkalis, can induce extensive damage to ocular surface, which is also common ocular trauma. Alkalis, especially strong alkalis, may penetrate the corneal stroma and destroy the anterior segment, while acid-induced eye injuries are more confined to the surface (Fig. 1.1).

1.3 Classification of Ocular Trauma

1.3.1 Introduction

Attempts have been made to clarify classification of ocular trauma along with definition for each type, which is critical for both ophthalmologists and non-ophthalmologists when describing and communicating clinical findings. With a standardized terminology and uniform classification system, it can enable the optical patient care as well as further evaluation of the efficacy of medical interventions, analysis of trends of ocular trauma, and accurate transmission of clinical data overall more applicable [16].

1.3.2 Birmingham Eye Trauma Terminology (BETT)

BETT has been endorsed by authoritative eye organizations including the American Academy of Ophthalmology, United States Eye Injury

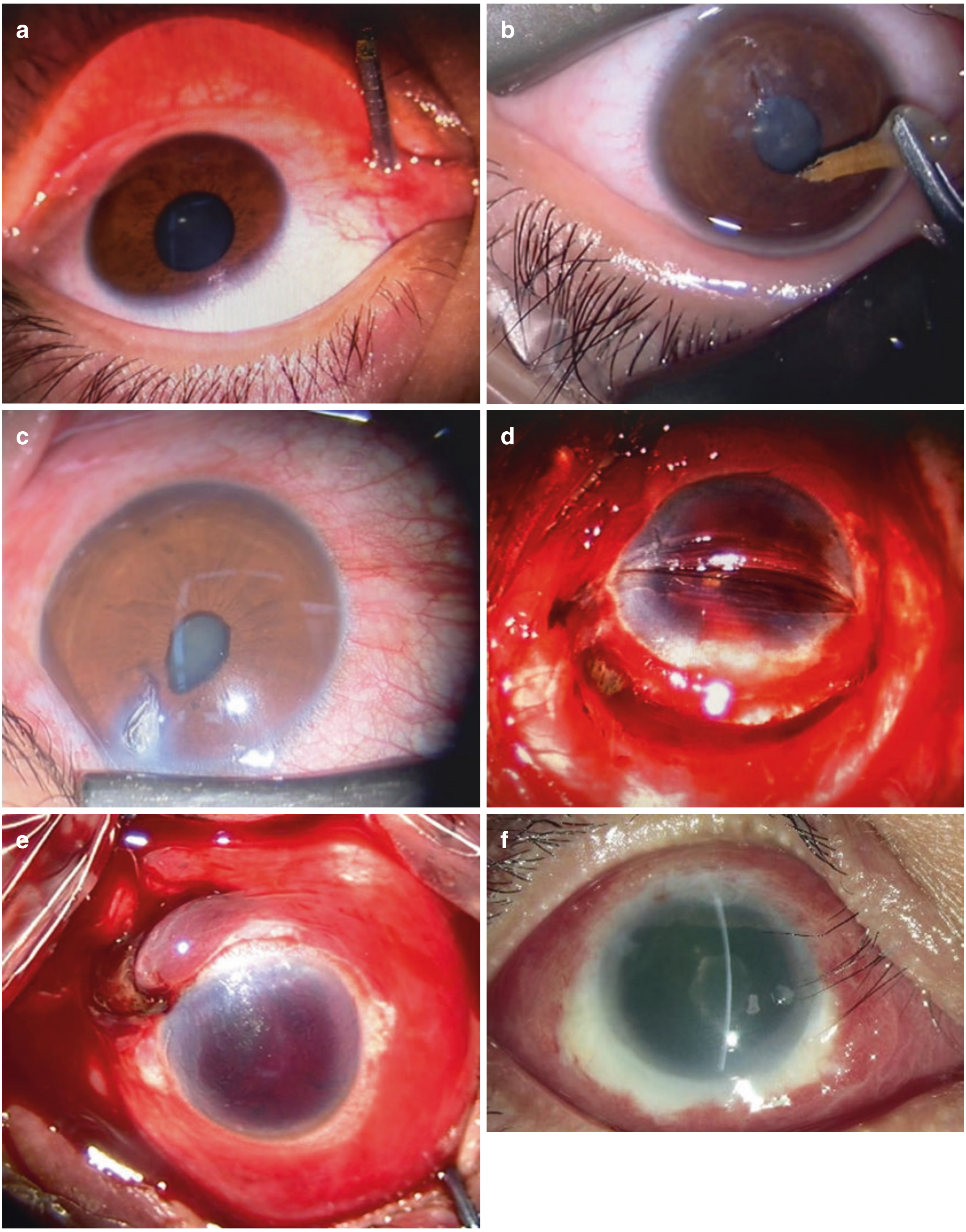

Fig. 1.1 Various types of ocular injuries caused by different sources. (**a**) A stainless steel nail went through the eyeballs inferior nasally causing ocular perforation, 7 mm behind the limbus (Zone III). (**b**) Ocular perforation caused by wooden debris inserted into the cornea at 5 o'clock. (**c**) An irony debris was stuck in the cornea resulting in corneal laceration (Zone I). (**d**) Ocular perforation induced by metal object. (**e**) Ocular rupture (Zone II) caused by fighting unexpectedly, with ocular structure (iris, retina, vitreous) stuck in the scleral laceration and dense hyphema. (**f**, **g**) Chemical ocular injury induced by acid and alkali, respectively. (**h**) Corneal opacity and chemosis resulting from heat

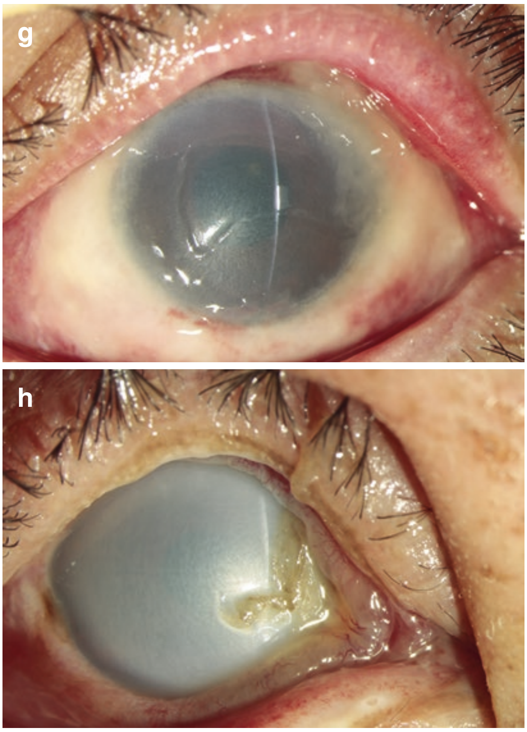

Fig. 1.1 (continued)

Registry and its 25 international affiliates, and so on. In BETT, criteria have been made as following: each term has a unique definition, which can not be used for two different injury types. Likewise, no injury type can be described by different terms [17]. Table 1.1 provides clear definitions for all types of ocular trauma, while Fig. 1.2 places a comprehensive system of ocular trauma types in framework [18].

1.3.3 Ocular Trauma Classification

The Ocular Trauma Classification Group has developed a classification system based on BETT and characters of eye injuries obtained in the initial observation [17]. Firstly, ocular trauma has been divided into two major groups, i.e., mechanical ocular trauma and nonmechanical ocular trauma due to chemical, electrical, or thermal agents, depending on the basic source of trauma [20]. The above system is a relatively comprehensive category system for mechanical

Table 1.1 Terms and definitions in BETT [18] (Reproduced with permission from [19])

Term	Definition and comment
Eyeball	Sclera and cornea *Although technically the eyeball has three coats posterior to the limbus, for clinical and practical purposes, violation of only the most external structure is taken into consideration*
Closed globe injury	No full-thickness wound of the eyeball
Open globe injury	Full-thickness wound of the eyeball
Contusion	There is no (full-thickness) wound *The injury is due to either direct energy delivery by the object* (e.g., *choroidal rupture) or the changes in the shape of the globe* (e.g., *angle recession)*
Lamellar laceration	Partial-thickness wound of the eyeball
Rupture	Full-thickness wound of the eyeball, caused by a blunt object *Because the eye is filled with incompressible liquid, the impact results in momentary increase in IOP. The eyeball yields at its weakest point (at the impact site or elsewhere;* e.g., *an old cataract wound dehisces even though the impact occurred elsewhere); the actual wound is produced by an inside-out mechanism*
Laceration	Full-thickness wound of the eyeball, caused by a sharp object *The wound occurs at the impact site by an outside-in mechanism*
Penetrating injury	Entrance wound *If more than one wound is present, each must have been caused by a different agent* Retained foreign object(s) *Technically a penetrating injury but grouped separately because of different clinical implications*
Perforating injury	Entrance and exit wounds *Both wounds caused by the same agent*

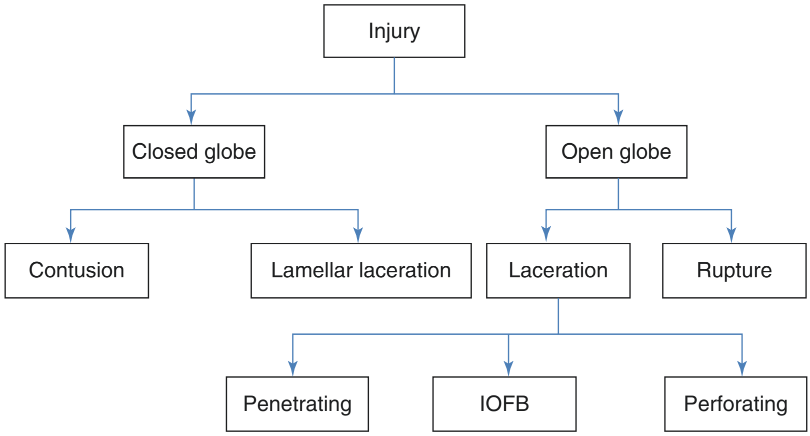

Fig. 1.2 Ocular trauma system made according to BETT, and the bold frames are widely used in the clinic (Reproduced with permission from [19])

Table 1.2 Ocular Trauma Classification System (OTCS) (Reproduced with permission from [22])

	Open globe injury classification	Closed globe injury classification
Type	Rupture Penetrating Intraocular foreign body Perforating Mixed	Contusion Lamellar laceration Superficial foreign body Mixed
Grade (visual acuity)[a]	≥20/40 20/50–20/100 19/100–5/200 4/200 to light perception No light perception[b]	≥20/40 20/50–20/100 19/100–5/200 4/200 to light perception No light perception
Pupil	RAPD(+) RAPD(−)	RAPD(+) RAPD(−)
Zone[c] (Fig. 1.2)	I: Isolated to cornea (including the corneoscleral limbus) II: Corneoscleral limbus to a point 5 mm posterior into the sclera III: Posterior to the anterior 5 mm of the sclera	I: External (limited to the bulbar conjunctiva, sclera, cornea) II: Anterior segment (involving structures in anterior segment internal to the cornea and including the posterior lens capsule; also includes pars plicata but not pars plana) III: Posterior segment (all internal structures posterior to the posterior lens capsule)

[a]Measured at distance (20 ft., 6 m) using Snellen chart or Rosenbaum near card, with correction and pinhole when appropriate
[b]Confirmed with bright light source and the fellow eye well occluded
[c]Requires B-scan ultrasonography when media opacity precludes assessment of more posterior structures

ocular trauma with four parameters considered ideally: type, grade, presence/absence of a relative afferent pupillary defect (RAPD), and extent of the injury (zone). This system helps us have a better understanding of the pathophysiological ramifications and make appropriate therapeutic strategy for different ocular trauma types [21] (Table 1.2 and Fig. 1.3).

1.3.4 The OTS: Predicting the Final Vision in the Injured Eye

Although vision acuity is not the only outcome factor after injury, however, it is the most significant one that is related to high life quality quite closely. Hence, it is extremely important and efficient to propose a relatively accurate prediction

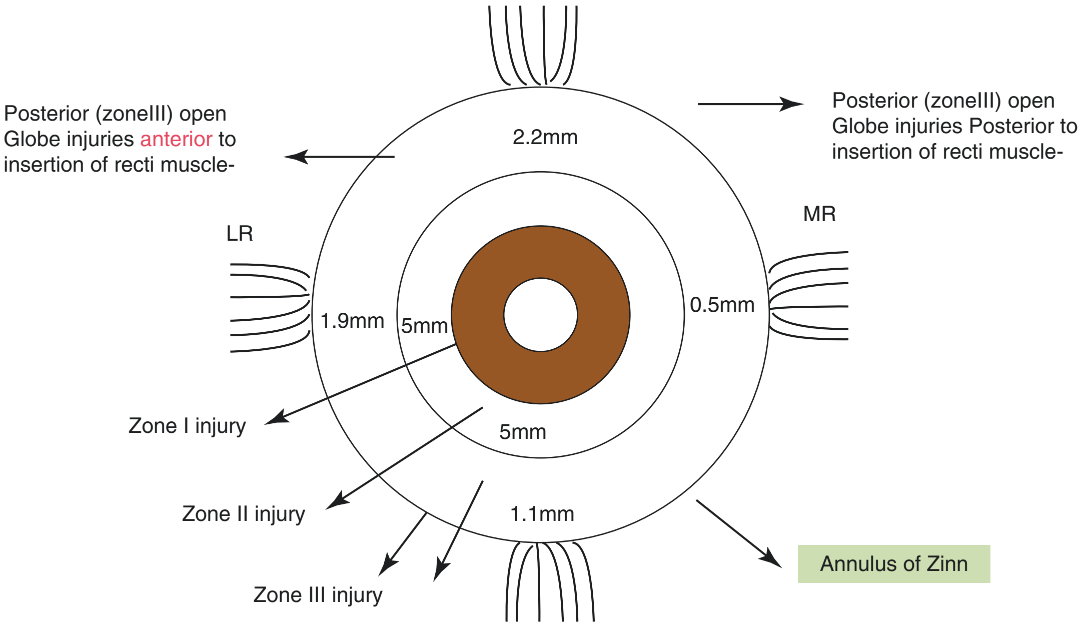

Fig. 1.3 Zone of ocular trauma in OTCS (Reproduced with permission from [22])

of vision recovery as soon as the ocular trauma occurred. Unfortunately, there is no comprehensive method to evaluate objectively the eye's functional outcome [23]. On the basis of BETT and information from studies about the prognostic significance, taking a limited number of important variables into consideration, the team developed the OTS system to help the ophthalmologists prognosticate the outcomes of eye trauma [24]. Having access to early prognostic information allows appropriate counseling of the patient and contributes to making the correct triage and management decisions. OTS is very simple to perform with three steps shown in Table 1.3 [21].

1.4 Pearls and Tips

1. Ophthalmologists in the emergency room are typically able to determine the types of the ocular trauma, and forceful investigations (open squeezed eyelids) must never be attempted.
2. Details about ocular trauma need to be collected comprehensively on the initial examination, and type, grade, presence/absence of a relative APD, and extent of injury are ideally evaluated after determination of open or closed globe injury.
3. Precise confirmation of zone or severity of ocular trauma is frequently determined after surgical exploration of ocular wound.
4. A comprehensive and standardized eye trauma surveillance system in a defined population to identify risk factors needed to be set up and maintained in daily clinic.
5. The OTS uses a limited number of variables (readily determined at the time of the initial evaluation or surgery) and basic mathematics to give the ophthalmologist a 77% chance to predict the final functional outcome within one visual category shortly after the eye injury. Having access to early prognostic information allows appropriate counseling of the patient and contributes to making the correct triage and management decisions [18].
6. More public educations should be organized to minimize the incidence of ocular trauma in high-risk population and occasions. Additionally, providing useful information regarding prevention (use of safety eyewear, its type and availability, and instructions for use) is also necessary.

Table 1.3 Ocular Trauma Score (OTS) (Reproduced with permission from [22])

Step 1	Variables used	Raw points
A	Initial vision	
	NLP LP/HM 1/200–19/200 20/200–20/50 ≥20/40	60 70 80 90 100
B	Perforating injury	−14
C	Retinal detachment	−11
D	APD	−10
E	Rupture	−23
F	Endophthalmitis	−17
Step 2 Calculating the sum of the raw points: A + B + C + D + E + F		
Step 3 Conversion of raw points into the OTS and calculating the likelihood of the final visual categories		

Sum of the raw points	OTS	NLP	LP/HM	1/200–19/200	20/200–20/50	≥20/40
0–44	1	74%	15%	7%	3%	1%
45–65	2	27%	26%	18%	15%	15%
66–80	3	2%	11%	15%	31%	41%
81–91	4	1%	2%	3%	22%	73%
92–100	5	0%	1%	1%	5%	94%

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2 Conjunctival Injury

Bo Qin and Sheng Chen

Abstract

The conjunctiva is divided into three parts: the eyelid conjunctiva, the bulbar conjunctiva, and the fornix conjunctiva. Trauma or inflammation can cause conjunctiva cicatricial contraction. The fornix conjunctiva is thicker with larger mobility. The bulbar conjunctiva binds loosely with the underlying fascia, forming a potential gap, which is prone to edema during trauma. Conditions including conjunctival trauma, conjunctival edema and bleeding, are often accompanied by conjunctival sac or conjunctival wound with foreign bodies, such as sands, hairs, scrap iron and so on. Patients may have eye pain, foreign body sensation, tears, and other symptoms. This chapter includes two sections (four cases with brief descriptions, illustrating figures and personal tips and tricks), aiming to provide a guide about diagnosis and management of conjunctival injuries.

Keywords

Conjunctival injury · Laceration · Foreign body

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2.1 Conjunctival Laceration

2.1.1 Introduction

Conjunctival injury is a very common condition that presents as an ocular emergency. When conjunctival laceration has been confirmed, the conjunctiva should be examined for the presence of chemosis, subconjunctival hemorrhage, emphysema, foreign bodies, and abrasions. The presence of hemorrhagic chemosis may indicate scleral rupture. Conjunctival emphysema (visible air in a subconjunctival location) may indicate the presence of a sinus fracture. The conjunctival laceration can be detected by fluorescein stain. If a conjunctival laceration is present, it is vital to rule out underlying scleral lacerations or foreign bodies with a careful examination under topical anesthesia. Once it is determined that an open globe injury is not present, the upper eyelid should be everted, and the superior tarsal conjunctiva should be examined for the presence of foreign bodies. If suspicion exists, the superior conjunctival fornix can also be examined directly for the presence of foreign bodies [1]. Most of the conjunctival foreign bodies occur in explosive injuries. Conjunctival lacerations are often caused by foreign body trauma. One very frequent cause is inadvertent fingernail injury, often caused by small children inadvertently striking caretakers or between adults during a sporting

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event. Machine workers and other fabrication and construction workers are also considered high-risk [1]. Now we will give a case to illustrate.

2.1.2 Case: The Eye Hit by "Basketball"

A 40-year-old male security guard complained of pain, redness, and watering in the left eye after hitting by a basketball 3 h ago. The visual acuity of the left eye did not show significant decrease (20/25). A 12 mm regular and vertical laceration can be seen in the nasal conjunctiva, and the conjunctiva was hyperemic and swollen. The other ocular structure was normal (Fig. 2.1). The intraocular pressure was 14 mmHg. Though the laceration can be covered mostly by the lids, the irritation was still noteworthy. Emergency suture of the conjunctiva was conducted in the left eye, and the suture was removed after 7 days.

2.1.3 Tips and Pearls

Examination should contain a complete ocular examination including a dilated fundus examination to rule out a more serious injury. Every conjunctival laceration should be explored extensively under topical anesthesia. Most small conjunctival lacerations can be treated conservatively with prophylactic topical antibiotics for 5–7 days. Antibiotic ointments are often utilized as their lubricating properties contribute to the patient's comfort, although topical drops will surface.

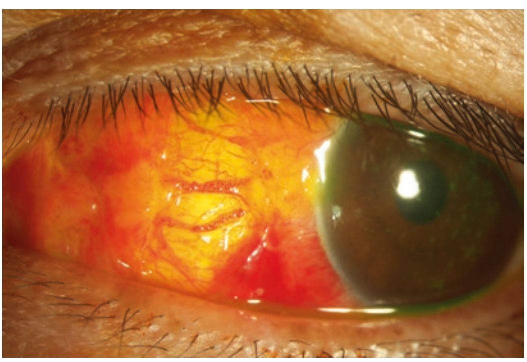

Fig. 2.1 The slit lamp image of the left eye showing a 12 mm regular and vertical conjunctival laceration on nasal side with conjunctival hemorrhage by fluorescein stain

Most small lacerations (<10 mm) will heal quickly without surgical intervention. Larger (>10 mm), poorly approximated, and horizontally oriented conjunctival lacerations should often be sutured. A horizontally oriented laceration often comes in contact with the lid margin during blinking. Like this patient, he is lucky only with a conjunctival injury not corneal, eyelid, or other ocular structure injuries. Large or poorly approximated lacerations may leave scar tissue and produce a chronic foreign body sensation. Absorbable suture should be sufficed to cover bare sclera and can be done in a minor operating room or even at the slit lamp.

Isolated small lacerations treated only with prophylactics can be seen on as-needed basis if their recovery is unremarkable. More extensive or sutured lacerations should be evaluated in 5–7 days [1].

2.2 Conjunctival Foreign Bodies

2.2.1 Introduction

Most of conjunctival foreign bodies could be easily found due to its superficial location. The foreign bodies could come in any forms or types, such as eyelash, iron scur, lime, and so on. These ocular injuries often happen in people like children or factory workers. Though we can see most foreign bodies located on the conjunctiva directly, a detailed history inquiry and examination are necessary. It is possible that foreign bodies hide in fornical conjunctiva or upper eyelid conjunctiva, and it should be examined for the presence of chemosis, subconjunctival hemorrhage, emphysema, other foreign bodies, abrasions, or lacerations. At the same time, it's important to check up the residual foreign bodies in other ocular structures. The foreign bodies should be taken out as soon as possible. We give some cases to explain the examination, treatment, and notes.

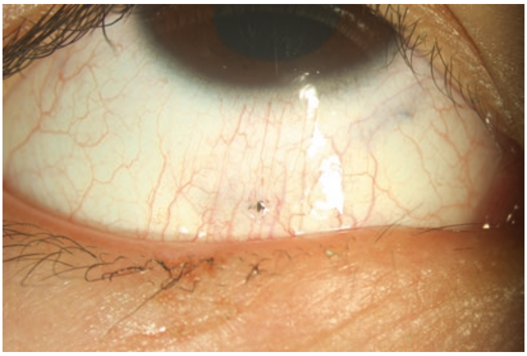

Fig. 2.2 The slit lamp image of the right eye showing a foreign body lied in the lower tarsal conjunctiva with no conjunctival abrasions or laceration

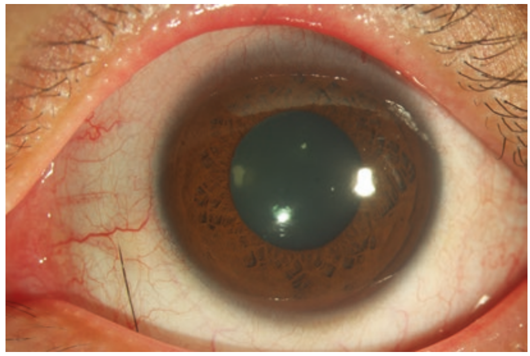

Fig. 2.3 The slit lamp image of the left eye showing an eyelash in the paranasal conjunctiva

2.2.2 Case #1: The Foreign Body in the Eye

A 36-year-old male presented with pain and foreign body sensation in the right eye for 1 day. Slit lamp examination revealed foreign body in the lower tarsal conjunctiva, no abrasions or laceration. The cornea is hyaline, and no injury was found in other ocular structures (Fig. 2.2). The best visual acuity is normal (20/20).The intraocular pressure was 12 mmHg. The conjunctiva was a little swollen. The foreign body was removed with a wet cotton-tipped swab, which is an iron dust. To prevent future infection, antibiotic eye drops were given four times a day.

2.2.3 Case #2: The Foreign Body in the Eye

A 25-year-old woman, who complained of ocular discomfort for 1 day, without any ocular disease history, came to ophthalmic emergency clinic. The patient found eyelash in the eye 1 day ago, and several attempts have been tried to take out the foreign body but failed. Slit lamp examination revealed the eyelash in the paranasal conjunctiva, with light hyperemic conjunctiva (Fig. 2.3). The eyelash was removed with a microforceps. Antibiotic eye drops were given four times a day.

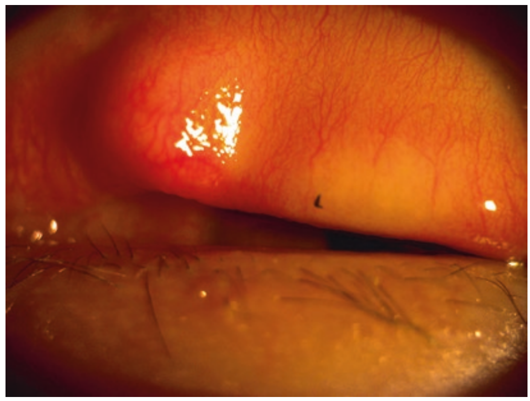

Fig. 2.4 The slit lamp image of the right eye showing a foreign body in the upper tarsal conjunctiva with conjunctival congestion

2.2.4 Case #3: The Foreign Body in the Eye

A 35-year-old man presented to our emergency clinic, with the chief complaint of splash into his right eye by a foreign body occurring neglectful 3 h ago. The patient has a serious and uncomfortable ocular feeling. Slit lamp examination revealed a foreign body in the upper tarsal conjunctiva, with conjunctiva hematodes (Fig. 2.4). The intraocular pressure was normal. The foreign body was removed by a wet cotton-tipped swab, which was then found to be a slice iron. Antibiotic eye drops were used to prevent potential infection for 3 days.

2.2.5 Tips and Pearls

Recognizing and treating any ocular injuries is the first and most important step. The best treatment for conjunctival foreign body is timely removal of the foreign body, especially metallic foreign body. Patients with metallic foreign body can be followed on as-needed basis assuming a routine recovery. It's important to check carefully for foreign residual body [1].

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3 Corneal Injury

Weiyun Shi and Ting Wang

Abstract

This chapter covers corneal injuries including corneal abrasion, corneal foreign body injury, and corneal laceration. A corneal abrasion is a traumatic injury involving the corneal epithelium. A corneal foreign body injury refers to a foreign object intruding and embedded in any layer of the cornea. A corneal laceration is a partial- or full-thickness cut on the cornea. Twelve cases are presented with brief descriptions, illustrating figures, and personal tips and peals, aiming to provide a guide to the diagnosis and management of corneal injury.

Keywords

Corneal abrasion · Corneal foreign body injury · Corneal laceration

3.1 Corneal Abrasion

3.1.1 Introduction

When the corneal surface is touched or abraded by some rough object, corneal abrasions of different degrees, mainly epithelial defects or exfoliation [1, 2], will result. In this section, abrasions in the superficial cornea without stromal laceration are described, and those extending to the stroma are excluded. Foreign body sensation, pain, photophobia, and tearing are major symptoms of corneal abrasions. If the treatment is delayed, corneal infection or ulceration may occur. Abrasions in the corneal center have a great impact on vision.

3.1.2 Case #1: A Corneal Abrasion by an Exposed Suture for Double Eyelids

3.1.2.1 Case Description

A 24-year-old female patient was referred to our hospital with redness, pain, tearing, and decreased vision in the right eye. Corneal epithelial defects repeatedly occurred in the past 1 month. Slit-lamp microscopic examination showed a 2-mm epithelial defect and a localized ulcer in the superior temporal cornea (Fig. 3.1). Sodium fluorescein staining revealed the lesion area, with several linear epithelial stainings around the lesion (Fig. 3.2). Optical coherence tomography (OCT) demonstrated that the lesion reached the superficial stroma (Fig. 3.3). Based on the morphology, corneal abrasion was considered to be the cause. Then secretions were

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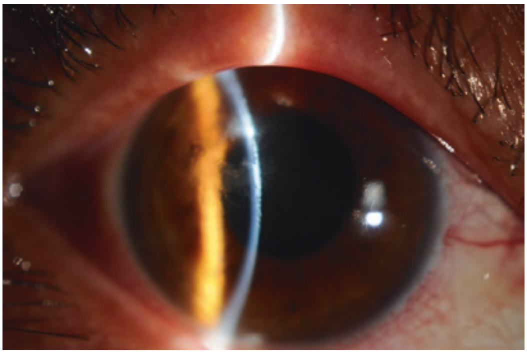

Fig. 3.1 Slit-lamp appearance of epithelial defection and localized ulceration and infiltration in the superior temporal cornea

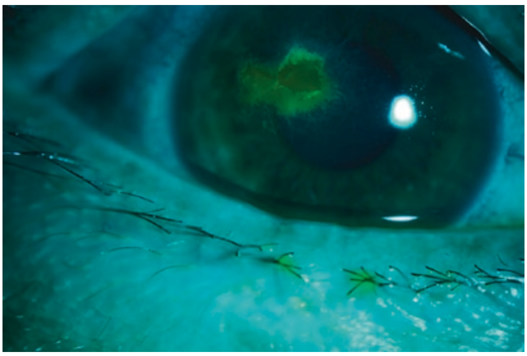

Fig. 3.2 Fluorescein staining revealing the lesion area, with abrasive lines in the epithelium

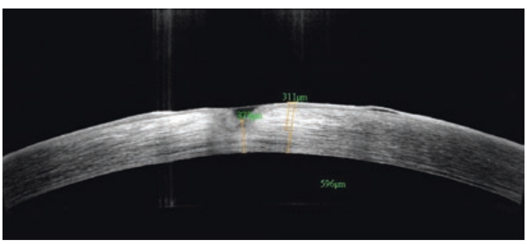

Fig. 3.3 OCT showing an anterior stromal corneal ulcer

observed on the temporal side of the upper eyelid and erased, before a linear foreign body was felt near the fornix by pressing the eyelid (Fig. 3.4). The patient was asked once again about any surgery history, and she reported to receive double eyelid plasty with an embedded suture 3 years ago. After the exposed suture was removed, antibiotic ointment and corneal repair

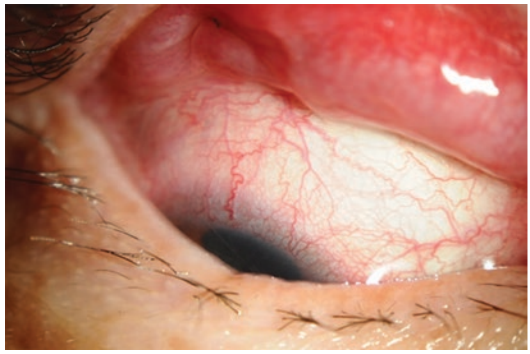

Fig. 3.4 Suture exposure near the superior fornix corresponding to the position of the corneal ulcer

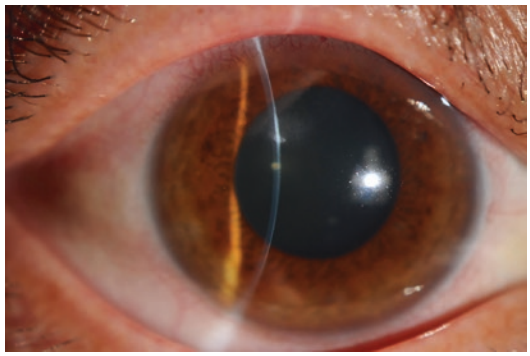

Fig. 3.5 Complete healing of the corneal ulcer at 5 days after the removal of the exposed suture

gel were administered. The corneal ulcer completely healed within 5 days (Fig. 3.5). No recurrence was found during the follow-up.

3.1.2.2 Tips and Pearls

It is important to eliminate the predisposing factor in the management of corneal abrasions as a kind of transient trauma. The exposure of an eyelid suture was the etiology in this case but was not realized initially. Another tip is to patch the injured eye for reduction of motion friction and promotion of epithelial repair. The advent of bandage soft contact lenses leads to not only better protection of epithelial cells and healing of epithelial wounds but also alleviation of patient discomfort [3]. Moreover, administration of antibiotics should not be neglected for prevention of corneal infection associated with epithelial defection [4].

Patients with corneal abrasions usually have a history of ocular trauma or eye scratching with a foreign body. Slit-lamp microscopy is commonly used to examine the abraded cornea and resultant epithelial exfoliation. Corneal staining using sodium fluorescein is helpful in observing corneal epithelial defects and determining the extent of injuries.

3.1.3 Case #2: A Corneal Abrasion by a Sleeve

3.1.3.1 Case Description

A 46-year-old female patient presented with foreign body sensation half a day after the left eye was rubbed by a coat sleeve. The visual acuity was 0.6. Epithelial roughness and abrasion of 2 mm × 4 mm were visible in the paracentral cornea (Fig. 3.6). OCT examination revealed only the corneal epithelium was involved (Fig. 3.7).

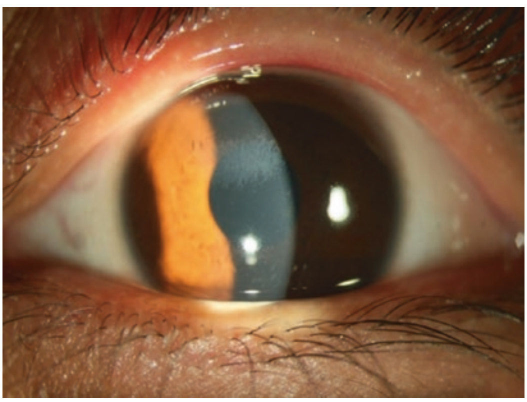

Fig. 3.6 An abrasion in the upper paracentral corneal epithelium

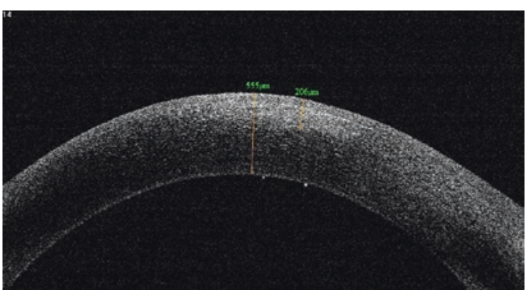

Fig. 3.7 OCT showing the involvement of the corneal epithelium

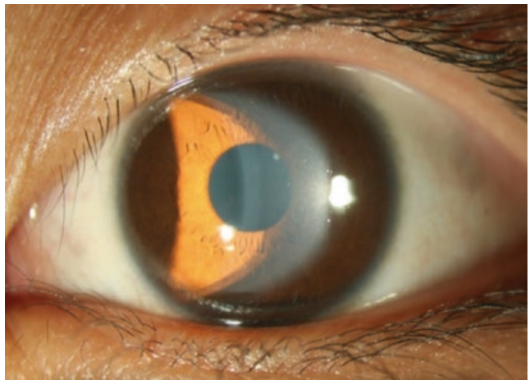

Fig. 3.8 The repaired corneal epithelium after 2 days of medication

The wound healed 2 days after the eye was covered with antibiotic ointment (Fig. 3.8).

3.1.3.2 Tips and Pearls

Patching the injured eye for reduction of motion friction and promotion of epithelial repair is of great importance. Moreover, administration of antibiotics should not be neglected for prevention of corneal infection associated with epithelial defection. Most corneal abrasions heal spontaneously without difficulty in 24–48 h and without scarring if Bowman's membrane is uninvolved.

3.2 Corneal Foreign Body Injury

3.2.1 Introduction

Corneal foreign body injuries are an ophthalmic emergency caused by the accidental entry into the cornea of foreign bodies such as droplets, small insects, metal fragments, and wood chips and the second commonest eye trauma following corneal abrasions. According to a study in northern Sweden, the incidence of eye injuries was estimated to be 0.81%, with corneal and conjunctival foreign bodies comprising 40% [5]. The frequently encountered symptoms include foreign body sensation, photophobia, and tearing. The irritation is often significant when the foreign bodies are in the superficial cornea [6], but unobvious in the event, they penetrate the deep layer. The latter may lead to delay in medical visit and resultant foreign body removal and even corneal

infection. The foreign bodies in the central cornea could greatly affect visual acuity.

3.2.2 Case #1: An Iron Foreign Body in the Cornea

3.2.2.1 Case Description

A 2-year-old male presented with decreased vision, foreign body sensation, and tearing in the right eye 3 days after a foreign body injury. The vision was 0.5, and the intraocular pressure (IOP) was 15 mmHg. Slit-lamp microscopy revealed an iron chip within the cornea (Fig. 3.9). By OCT examination, the foreign body was observed to partly invade the anterior chamber through the full-thickness cornea (Fig. 3.10). Surgery was performed to remove the foreign body. After the viscoelastic material, Healon, was injected into the anterior chamber, the Healon needle was used to push the iron chip from the endothelial side to prevent it from falling into the iris or lens.

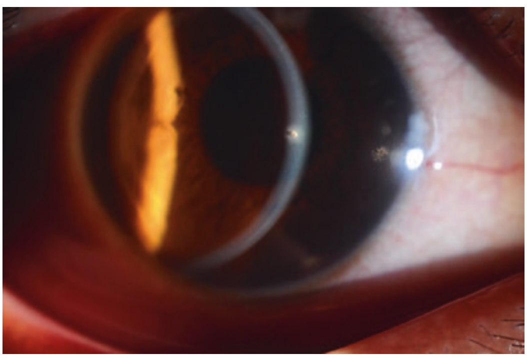

Fig. 3.9 A 0.5-mm iron chip affecting the deep corneal stroma for 3 days

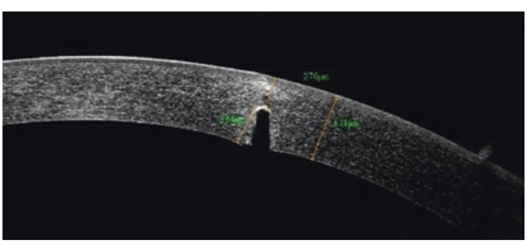

Fig. 3.10 OCT showing a part of the iron chip in the deep corneal stroma and another part in the anterior chamber, with the healed wound in the corneal epithelium and anterior stroma

The foreign body was successfully pushed out from the original wound (Figs. 3.11, 3.12, 3.13, and 3.14). The postoperative healing was good (Fig. 3.15), and the visual acuity improved to 0.8.

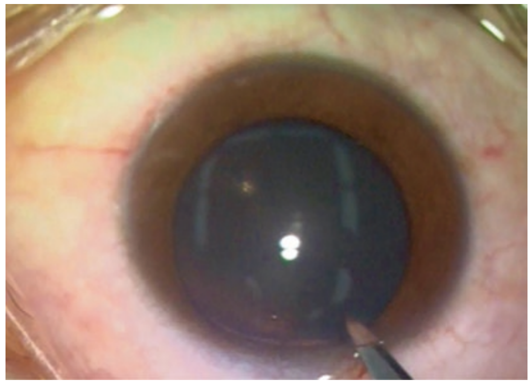

Fig. 3.11 A 1-mm incision is made at the lateral corneal limbus following peribulbar anesthesia

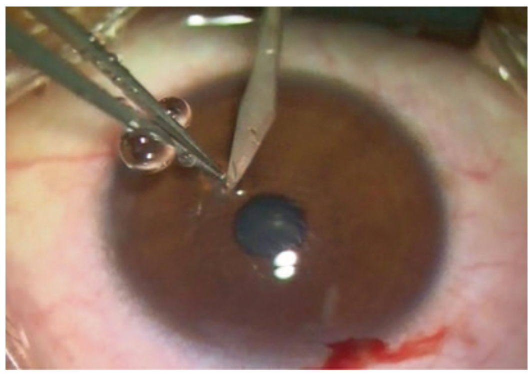

Fig. 3.12 Appropriate expansion of the incision on the corneal surface corresponding to the site of the foreign body

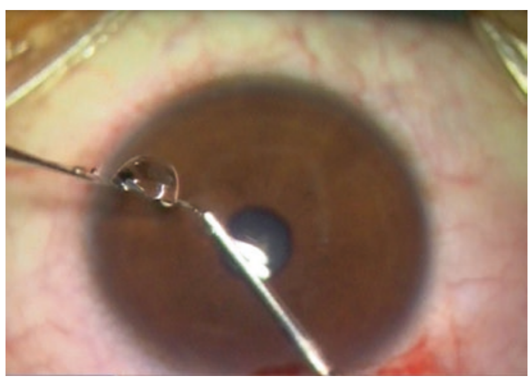

Fig. 3.13 After injection of a myotic agent and Healon into the anterior chamber, the foreign body is pushed out of the cornea by the Healon needle

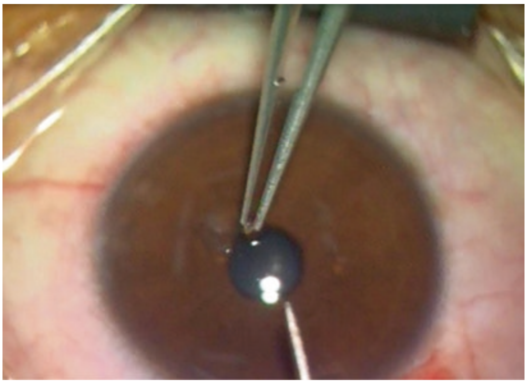

Fig. 3.14 The foreign body is held using forceps toothed 0.12 mm and removed from the corneal surface

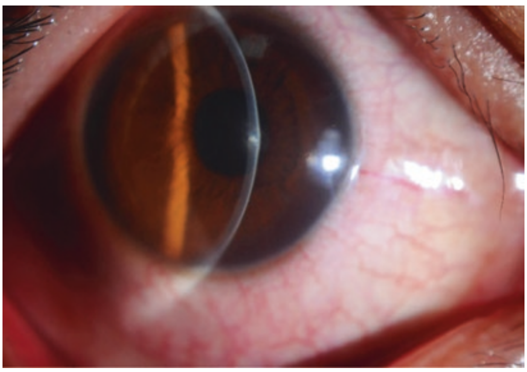

Fig. 3.15 Slit-lamp appearance of the corneal wound closure after foreign body removal

3.2.2.2 Tips and Pearls

During the diagnosis process, it is essential to inquire the patient history concerning ocular trauma and foreign body penetration. Slit-lamp microscopy is commonly used in the examination of corneal foreign bodies. If blepharospasm and irritation symptoms are obvious, topical anesthesia can be helpful. OCT examination assists in determining the depth of foreign bodies in the cornea and selecting appropriate surgical approaches.

Extraction of corneal foreign bodies, no matter what types they are, should be performed in time and followed by treatment against infection. When the foreign body penetrates into the anterior chamber with a part on the corneal surface, microforceps can be employed. If it mostly enters the anterior chamber with the tail in the stroma, a lateral corneal limbal incision can be created. After injection of Healon into the anterior chamber, the Healon needle is used to push it from the endothelium and make it back to the corneal surface. For any fragile or broken foreign body, it is also necessary to expand the incision to pull out the object, after which the corneal fissure must be sutured in the event of leakage in the cornea.

3.2.3 Case #2: A Glass Foreign Body in the Cornea

3.2.3.1 Case Description

A 45-year-old male had been injured with broken lenses of his spectacles 5 days earlier before he was referred to our hospital. The wound was sutured, but the lens fragment failed to be taken out at the local hospital. The visual acuity was 0.8. Slit-lamp microscopy showed sutures at the corneoscleral rim and a nasal limbal foreign body entering the anterior chamber (Fig. 3.16). OCT revealed the penetration of the lens fragment to the anterior chamber through all corneal layers and the healed corneal epithelium and anterior stroma (Fig. 3.17). After peribulbar anesthesia, a lateral limbal incision was created near the foreign body and enlarged on the corneal surface (Fig. 3.18). Healon was infused into the anterior chamber, before the foreign body was pushed from the endothelium using the Healon needle and back to the corneal surface and then held with 0.12-mm tooth forceps (Fig. 3.19). The corneal laceration was sutured with two 10-0 nylon stitches (Fig. 3.20). The vision remained at 0.8.

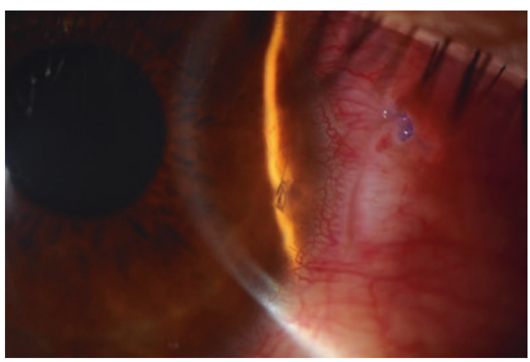

Fig. 3.16 Slit-lamp appearance of sutures at the nasal bulbar conjunctiva

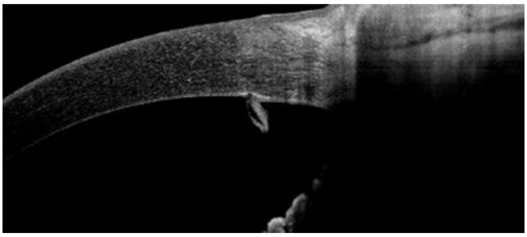

Fig. 3.17 OCT showing most of the lens fragment into the anterior chamber through the cornea

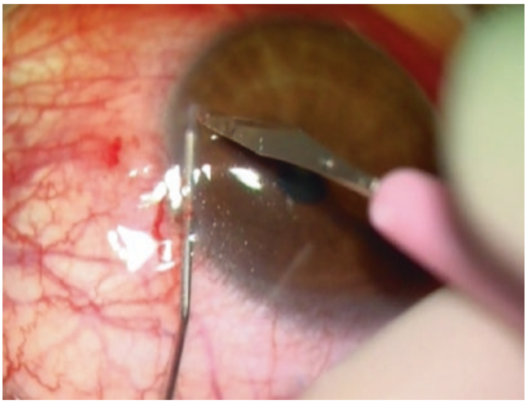

Fig. 3.18 A lateral corneal limbal incision is made near the foreign body and expanded on the corresponding corneal surface

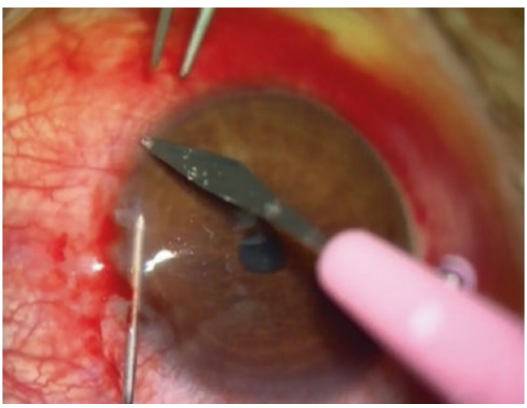

Fig. 3.19 After injection of Healon into the anterior chamber, the Healon needle is used to push the foreign body out of the cornea

3.2.3.2 Tips and Pearls

The lens fragment penetrates into the anterior chamber with a small part on the corneal stroma. A lateral corneal limbal incision should

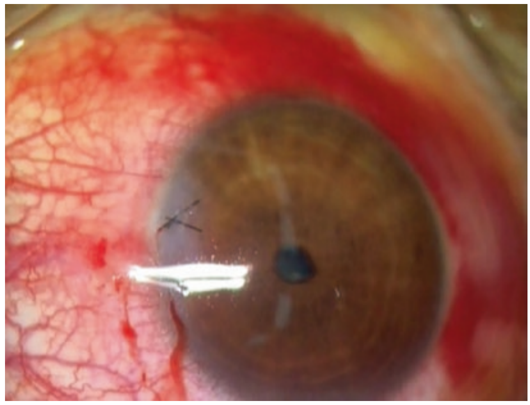

Fig. 3.20 Two interrupted sutures for the irregular corneal tear

be created. After injection of Healon into the anterior chamber, the Healon needle is used to push it from the endothelium and make it back to the corneal surface. We expand the incision to pull out the object, after which the corneal fissure had been sutured in the event of leakage in the cornea.

3.2.4 Case #3: Explosion-Related Multiple Foreign Bodies in the Cornea

3.2.4.1 Case Description

A 56-year-old male patient presented with multiple foreign bodies in the cornea of both eyes at 2 days after an explosion injury. He complained of foreign body sensation, decreased vision, and pain. The vision was 0.2 OD and 0.1 OS. Gravel and metal slags were visible on slit-lamp microscopy examination. The injury in the left eye was severer than the right eye (Figs. 3.21 and 3.22). Surgical interventions were given to remove the large number of foreign bodies at different depths. Over 200 tiny foreign materials were first removed from the middle and anterior corneal stroma and the conjunctiva of both eyes, leading to many wounds (Figs. 3.23 and 3.24) and corneal edema. To avoid excessive damage to the cornea, treatment was paused. At 2 weeks, the wounds almost healed, some foreign bodies in the deep layer shifted to the superficial,

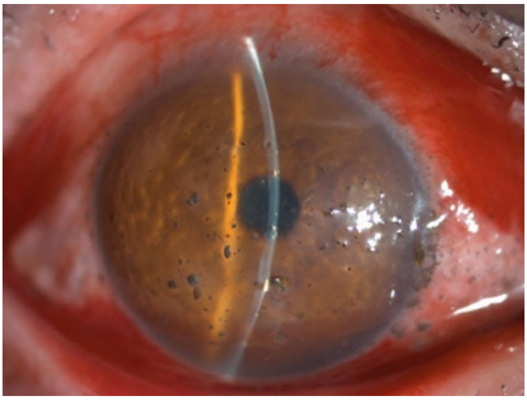

Fig. 3.21 A large number of gravel and metal slags in different sizes at all layers of the cornea, from the surface to the stroma, in the right eye

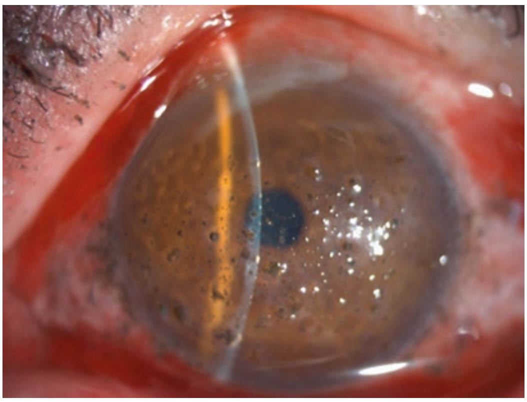

Fig. 3.22 Severer multiple corneal foreign body injuries in the left eye than the right eye

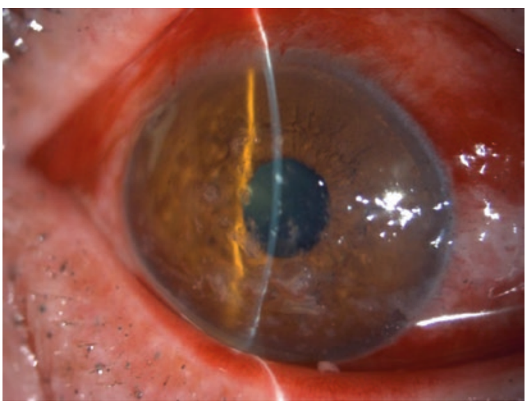

Fig. 3.23 Larger foreign bodies are removed, but tiny ones in the deep cornea are remained in the right eye during the first surgical procedure

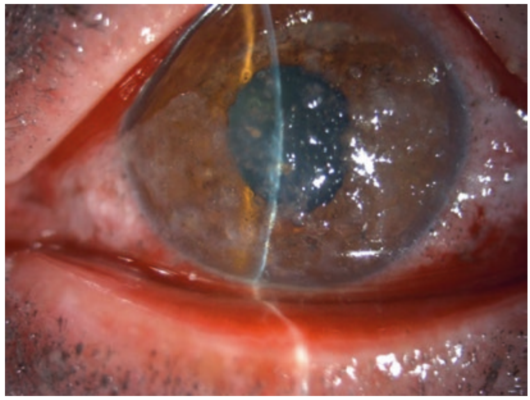

Fig. 3.24 Larger foreign bodies are removed, but tiny ones in the deep cornea are remained in the left eye during the first surgical procedure

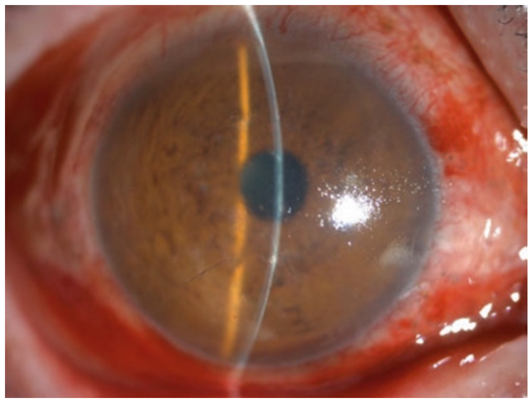

Fig. 3.25 The large incision is sutured with two stitches, and corneal transparency is restored in the right eye after the second surgical procedure

and then the second corneal and conjunctival foreign body removal was performed in combination with keratotomy for slags in the deeper cornea. Suturing was employed when necessary. There were still residual dustlike foreign bodies in the keratoconjunctiva, which were closely monitored in the follow-up. When redness and foreign body sensation occurred, low concentrations of topical glucocorticoids were administered to reduce the inflammation caused by foreign bodies. The visual acuity improved to 0.8 OD and 0.6 OS at 2 months (Figs. 3.25 and 3.26).

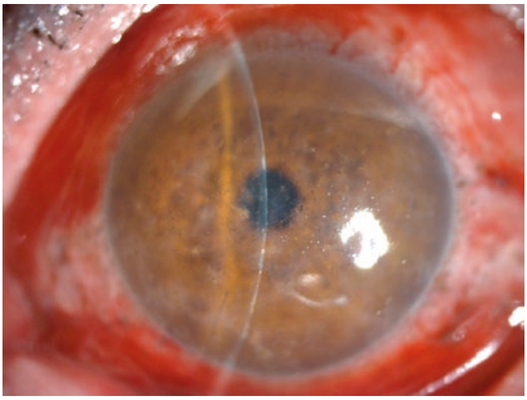

Fig. 3.26 The large incision is sutured with two stitches, and corneal transparency is restored in the left eye after the second surgical procedure

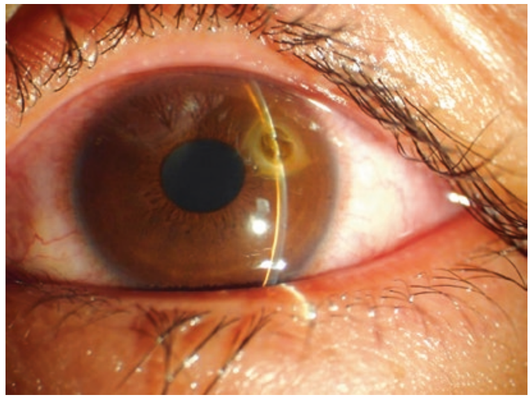

Fig. 3.27 Corneal infection at the site of foreign body removal, with temporal ulcerated infiltration of 2.5 mm × 2.5 mm and localized perforation, but no anterior chamber

3.2.4.2 Tips and Pearls

Multiple corneal foreign bodies, often caused by explosive injuries and manifesting as a large number of foreign materials of different sizes in all layers of the cornea, can be removed by stages. The foreign bodies exposed to the corneal surface and larger ones in the stroma, particularly iron objects, should be taken out as soon as possible, while those in the deep cornea can be removed when they shift to the superficial layer after a period of time. In eyes with widely spread foreign bodies and stromal opacity in the cornea, early partial corneal transplants are required for foreign body removal and visual acuity improvement.

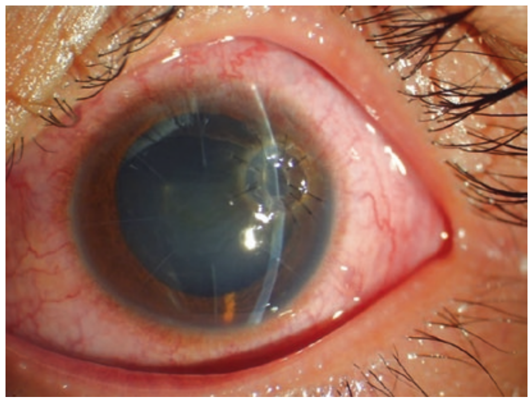

Fig. 3.28 Recovered anterior chamber and controlled infection after partial penetrating keratoplasty using a graft of 3-mm diameter

3.2.5 Case #4: Corneal Infection at the Site of Foreign Body Removed

3.2.5.1 Case Description

A 58-year-old female patient presented with decreased vision (0.02), redness, and pain in the left eye at 7 days after foreign body removal. Slit-lamp microscopy demonstrated corneal infection at the site from which the foreign body was removed, ulcerated infiltration of 2.5 mm × 2.5 mm at the temporal cornea, localized perforation, and no anterior chamber (Fig. 3.27). Considering the high rate of immune rejection after corneal transplantation with a large graft, small-diameter (3 mm) penetrating keratoplasty was performed for the peripheral corneal ulcer. Postoperatively, anterior chamber recovery, infection control (Fig. 3.28), and visual acuity of 0.5 were achieved.

3.2.5.2 Tips and Pearls

A rusty ring may occur and delay wound healing after an iron foreign body is kept in the cornea for 24 h [6]. After foreign body removal, the rusty ring can be taken out in one go if it does little harm to the cornea. In eyes with deep corneal ulceration, however, a rash operation may

lead to corneal perforation. When a large corneal lesion results from a big rust in the deep cornea, partial lamellar keratoplasty should be considered. If the cornea perforates, penetrating keratoplasty is required [7]. Corneal transplantation, also known as corneal grafting, is a surgical procedure where a damaged or diseased cornea is replaced by donated corneal tissue (the graft). When the entire cornea is replaced, it is known as penetrating keratoplasty, and when only part of the cornea is replaced, it is known as lamellar keratoplasty. Corneal infection is caused by foreign body, which can't be controlled by medicine. We should choose keratoplasty to save the cornea. Foreign bodies like plants and insects need to be noticed for the possible long-term sequelae in the cornea and other parts of the eye [8]. If infection develops, appropriate laboratory testing, particularly fungal detection, is required [7]. Moreover, significant inflammatory reactions associated with insect and arachnid parts in the cornea must be controlled. With time and corticosteroid therapy, residual hairs within the cornea might be resorbed [9–11].

Patients are routinely administered with local antibiotics after foreign body removal and advised to return for follow-up the next day in case of occurrence of corneal infection and resultant perforation due to delayed anti-infective management.

3.3 Corneal Laceration

3.3.1 Introduction

A corneal laceration refers to either a partial-thickness cut on the cornea, which does not lead to a tear into the eye globe, or a full-thickness injury to the cornea, which causes a ruptured globe.

The former is not accompanied by the exfoliation of ocular contents. Some small lamellar injuries can be self-healing, with mild symptoms. The latter may present with aqueous humor outflow and eye content protrusion or incarceration. The symptoms, including eye pain, tearing, and decreased vision, are comparatively severe.

3.3.2 Case #1: The Cornea Was Scratched by a Sheet of Plastic

3.3.2.1 Case Description

A 45-year-old male visited us with eye pain and decreased vision at 8 h after the right eye was scratched by a sheet of plastic. The visual acuity was finger counting at 20 cm. A longitudinal laceration on the central and nasal cornea, approximately 5 mm, was visible, and the depth of anterior chamber was normal (Fig. 3.29). It was found to be a lamellar injury by OCT examination, with edema in the affected corneal flap and irregular wound surface (Fig. 3.30). After suturing, the wound edges were matched well (Fig. 3.31). The postoperative vision was 0.5.

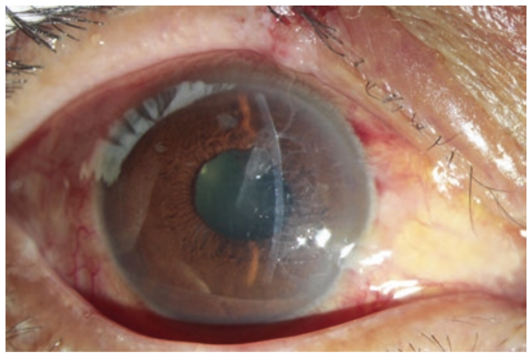

Fig. 3.29 A 5-mm longitudinal laceration on the central and nasal cornea

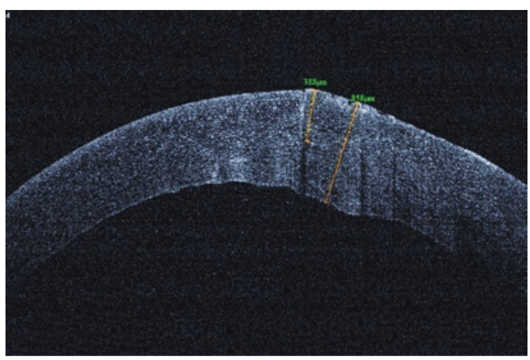

Fig. 3.30 OCT examination showing the partial-thickness laceration with an edematous corneal flap and irregular wound surface and poor matching

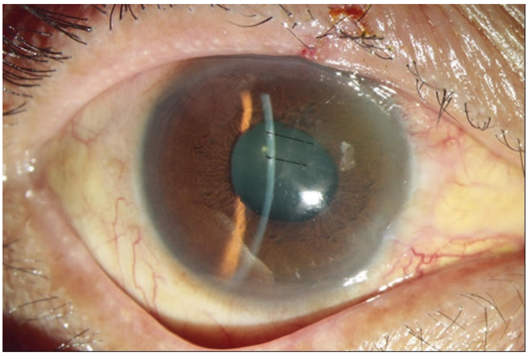

Fig. 3.31 Two interrupted sutures for matching of the wound edges

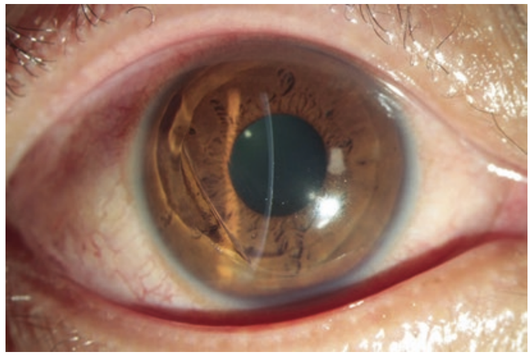

Fig. 3.32 A crescent temporal corneal flap dislocation at 7–10 o'clock positions after traumatic injury

3.3.2.2 Tips and Pearls

The purpose of treatment for partial- or full-thickness corneal laceration is to anatomically reapproximate corneal tissues. For mild and superficial lamellar corneal tears, a bandage contact lens is often sufficient. The laceration can become stable, and the stroma begins to heal after corneal epithelialization. If the cornea is partially distorted or the flap or bed is exposed or edematous because of delayed treatment, sutures are needed to reposition the tissue and allow healing [7].

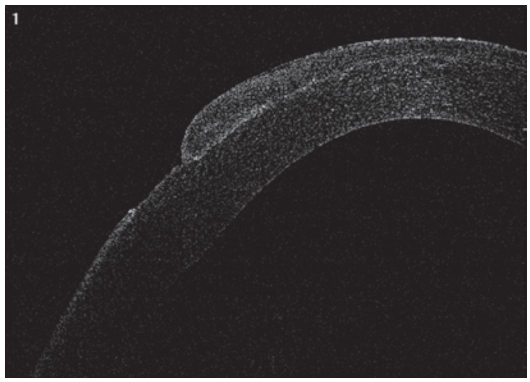

Fig. 3.33 OCT demonstrating the lamellar corneal laceration

3.3.3 Case #2: The Cornea Flap Was Scratched by Wardrobe Angle

3.3.3.1 Case Description

A 28-year-old patient presented with reduced vision and pain in the right eye half a day after scratched by wardrobe angle. He had received LASIK surgery 5 years earlier. Examinations revealed visual acuity of 0.4 and a crescent corneal flap displacement at 7–10 o'clock positions. By OCT examination, a partial-thickness corneal laceration, which did not penetrate completely through the cornea, was confirmed (Figs. 3.32 and 3.33). After the corneal flap was repositioned, a bandage contact lens was used. The wound healed well, and the vision recovered to 1.0 (Figs. 3.34 and 3.35).

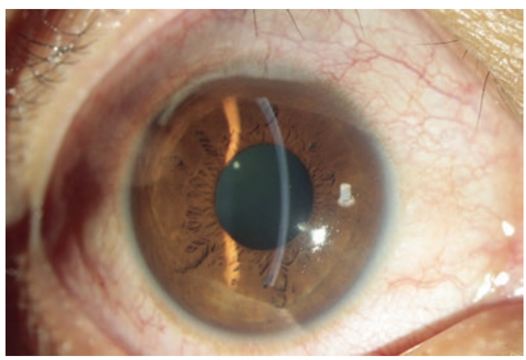

Fig. 3.34 Favorable healing at 1 week after corneal flap repositioning surgery

3.3.3.2 Tips and Pearls

Over the past 15 years, the rapid acceptance of laser in situ keratomileusis (LASIK) has resulted

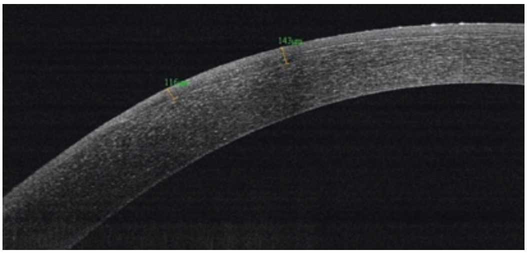

Fig. 3.35 OCT showing good healing after repositioning surgery

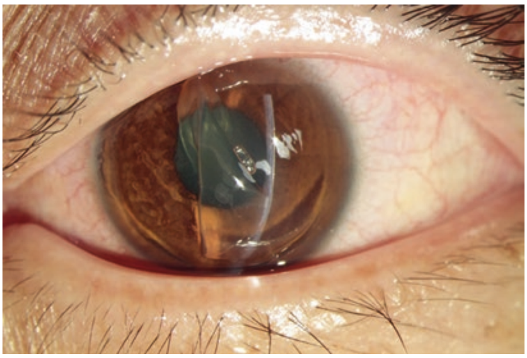

Fig. 3.36 An almost completely dislocated and partly folded corneal flap

in a large number of patients who have had this procedure on one or both eyes. Most ophthalmologists think that corneas that have undergone LASIK are at an increased risk of rupture following impact. The purpose of treatment for corneal flap laceration is to anatomically reapproximate corneal tissues. A bandage contact lens is sufficient in this case.

3.3.4 Case #3: The Cornea Flap Was Injured by Boxing

3.3.4.1 Case Description

A 32-year-old patient presented with reduced vision and pain in the left eye at 2 h after traumatic boxing injury. He had received LASIK surgery 10 years earlier. The visual acuity decreased to 0.02. An almost completely dislocated corneal flap was detected, a part of which

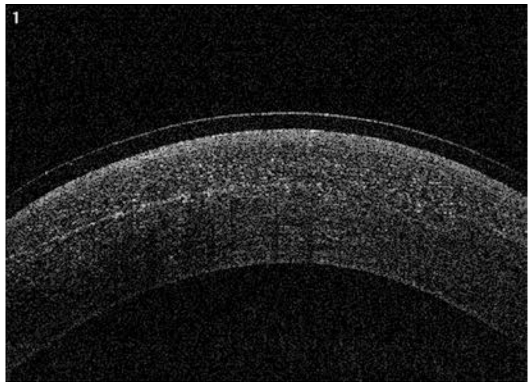

Fig. 3.37 OCT demonstrating the well-located bandage contact lens and corneal flap

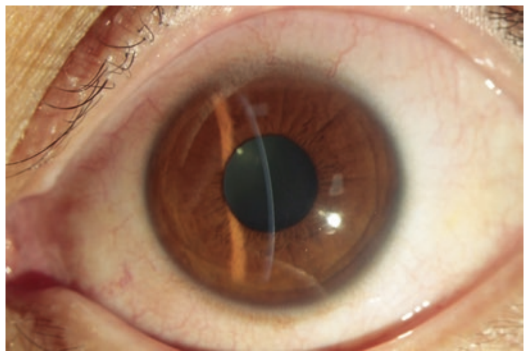

Fig. 3.38 Appearance of the clear cornea and good healing after removal of the bandage lens

was folded (Fig. 3.36). Surgery was performed to reposition the flap and followed by bandage contact lens wearing. OCT examination revealed the well-replaced corneal flap (Fig. 3.37). At 5 days after surgery, the bandage lens was removed, and the cornea became transparent, with healing of the corneal flap (Fig. 3.38) and improved visual acuity of 1.0.

3.3.4.2 Tips and Pearls

This corneal flap laceration after LASIK is more serious than case 2. And under the flap, the corneal epithelium had grown in. So before resetting the corneal flap, we must scavenge the corneal epithelium under the corneal flap. A bandage contact lens is effective in this case.

3.3.5 Case #4: A Cornea Stabbed by a Wire

3.3.5.1 Case Description

A male patient, aged 6 years, was referred to our institution 1 day after his eye was stabbed by a wire and sutured at the local hospital. Slit-lamp microscopy at that hospital showed a full-thickness 2-mm corneal perforation at the inferonasal pupil periphery, a loss of corneal tissue in the wound, and the anterior chamber disappearance (Fig. 3.39). The eyesight was 0.02, and the IOP was T-1. After the preliminary suture, the cornea presented with many folds because of the tissue absence and the tear tension (Fig. 3.40). The vision became finger counting before the eye. A second surgery was performed at our hospital by removing the sutures, transplanting a corneal graft in a size corresponding to the laceration (Fig. 3.41), and resuturing. The corneal folds disappeared (Fig. 3.42), and the visual acuity was improved to 0.5 at 2 weeks.

3.3.5.2 Tips and Pearls

Total corneal laceration is sometimes accompanied by corneal tissue defects. Large astigmatism is easily caused by simple laceration suture. Transplanting a corneal graft in a size corresponding to the laceration and resuturing is helpful to anatomic reduction and improvement of vision.

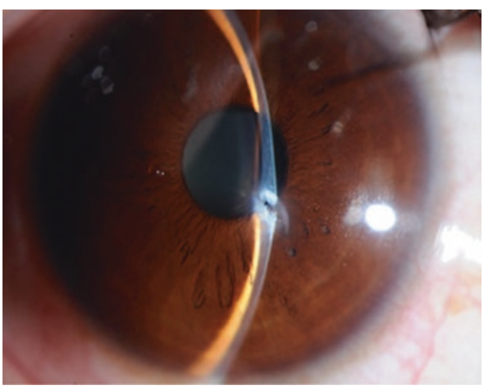

Fig. 3.39 An oval corneal injury from wire stabbing, with tissue loss and absence of the anterior chamber

Fig. 3.40 A large number of corneal folds after the first suture, with visual acuity of finger counting before the eye

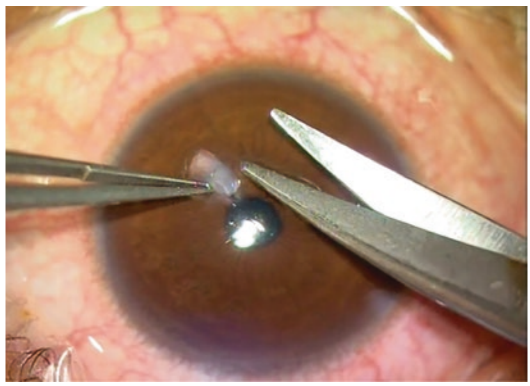

Fig. 3.41 A corneal patch graft for the tear

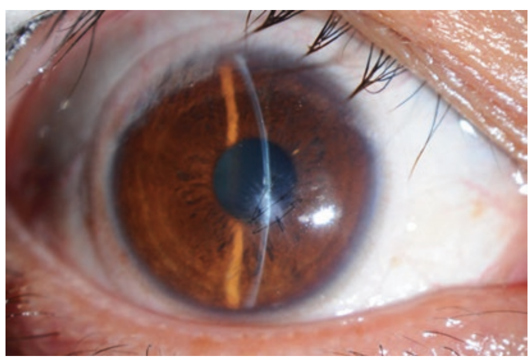

Fig. 3.42 The normal anterior chamber and no corneal folds after surgical treatment

3.3.6 Case #5: A Cornea Stabbed by Wire

3.3.6.1 Case Description

A 36-year-old male patient visited us at 2 h after wire stabbing, with visual acuity being hand movement at 20 cm. Slit-lamp microscopy showed the penetration of a wire into the cornea from the inferior nasal pupil periphery, the absence of the anterior chamber, and the lens rupture (Fig. 3.43). Surgery was performed to remove the foreign body and suture the laceration (Fig. 3.44). Treatment against infection was successfully given for 3 days, after which cataract surgery combined with intraocular lens implantation was performed (Fig. 3.45), achieving visual acuity of 0.6.

Fig. 3.43 All layers of the cornea stabbed by a wire, disappearance of the anterior chamber, and the ruptured lens

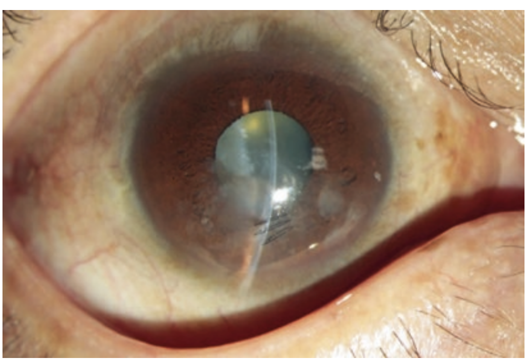

Fig. 3.44 The sutured corneal laceration after foreign body removal

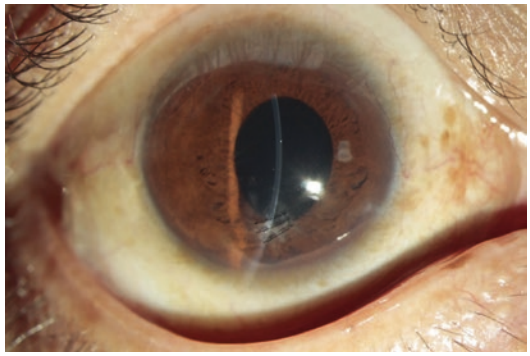

Fig. 3.45 The implanted intraocular lens in the eye receiving phacoemulsification

3.3.6.2 Tips and Pearls

Traumatic cataract is generally not treated at the same time, unless the lens cortex overflows into the anterior chamber. Cataract should not be extracted from the corneal fissure, and a corneal or scleral incision is required. If any retained foreign body or endophthalmitis is suspected after suture, B ultrasound scanning is needed. If conditions are allowed, the second cataract surgery is safer and more conducive to visual acuity.

3.3.7 Case #6: A Corneal Laceration by a Knife

3.3.7.1 Case Description

A 56-year-old female patient visited us half a day after injury to the right eye by a knife, presenting with decreased vision and eye pain. Examinations showed a visual acuity of 0.02 and a full-thickness 4-mm nasal corneal laceration, accompanied with the incarcerated iris, bulging cornea, filthy surface, almost disappeared anterior chamber, and opaque lens (Fig. 3.46). After the filth was cleaned as much as possible, the iris was repositioned and found to be partially aniridic. Then the corneal laceration was sutured with interrupted sutures (Fig. 3.47). At 3 months, the sutures were removed. When the corneal curvature became stable, cataract surgery was performed (Fig. 3.48), resulting in visual acuity of 0.5.

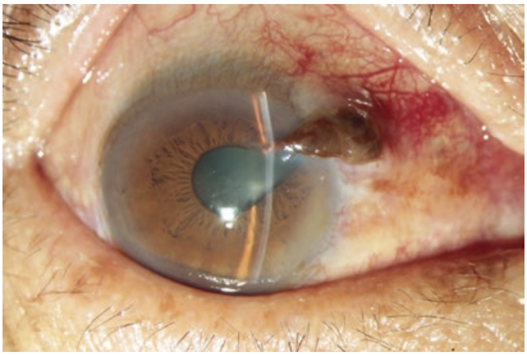

Fig. 3.46 A full-thickness 4-mm laceration in the nasal cornea, with the iris incarceration, corneal bulge, filthy surface, almost disappeared anterior chamber, and opaque lens

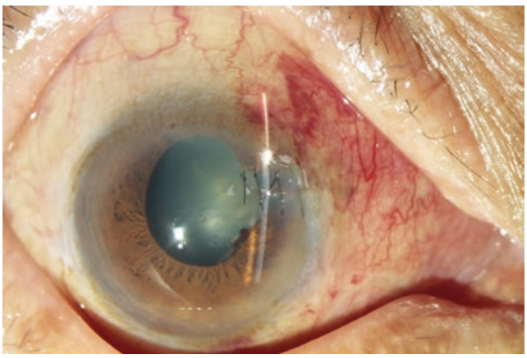

Fig. 3.47 The repositioned iris with partial absence and the sutured corneal laceration using interrupted sutures

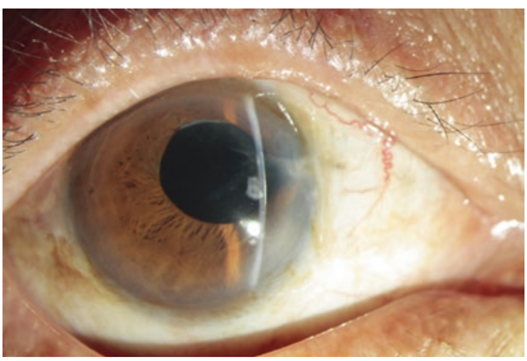

Fig. 3.48 After removal of corneal sutures and cataract surgery

3.3.7.2 Tips and Pearls

Tissue incarceration or prolapse is liable to develop in eyes with full-thickness corneal laceration. As long as the tissue is free of necrosis and severe infection, reposition should be tried.

The maximally tensioned part of a corneal laceration, usually the central part, should be sutured first. For patients with a corneal tear involving both the corneal limbus and the anterior sclera, however, the tip is to suture the corneal limbus first, so as to ensure the matching of all parts. The suture should reach 4/5 of the corneal thickness. Otherwise, anterior synechia may occur (Figs. 3.49 and 3.50). If the corneal laceration is large, the suture span is usually greater for the peripheral corneal part than the central. When an iris laceration coexists, it should not be treated via the corneal tear. Another surgery for iris or pupil repair is recommended [12].

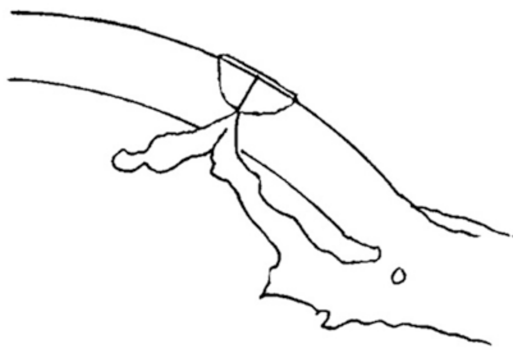

Fig. 3.49 A sketch of anterior synechia due to the poorly matched internal edges of a full-thickness corneal laceration after insufficient suturing

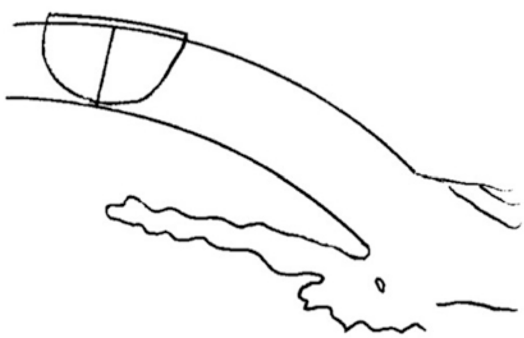

Fig. 3.50 A sketch of no anterior synechia after a full-thickness corneal laceration is sutured in a sufficient depth and the internal tear edges reapproximate well

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4 Iris and Ciliary Body Injury

Nan Wu, Zui Tao, and Hong Ji

Abstract

As you know, the iris and ciliary body are the middle part of the eyeball, continue with the cornea, and extend to the sclera, uvea, and retina. Traumatic injuries of the iris and ciliary body are usually caused by blunt eye injury but can result from any other type of injury, like firecrackers, pellet gun projectile, electric shock from Taser, fishing hook weight, motor vehicle accidents, batteries, water balloon slingshots, as well as many others. These injuries include hyphema, iridodialysis, and so on.

Keywords

Iridodialysis · Hyphema · Iris foreign body

4.1 Iridodialysis

Iridodialysis is the tearing of the junction between the iris and ciliary body, where the tissue is very thin and weak. It often occurs in the ocular blunt injury. During the blunt injury, the eyeball is oppressed, the pupil block occurs, the peripheral sclera expands, and the aqueous humor impacts the peripheral iris, causing tearing of the iris root from the ciliary body. This leads to the pupil deformation, pupil displacement, double pupil, or even traumatic aniridia (Fig. 4.1). If the condition causes obvious photophobia, monocular diplopia, or visual disorder, the iridodialysis should be repaired by surgical reconstruction. Serious ocular blunt injury often has other complications, such as lens dislocation, vitreous hemorrhage, and retinal detachment, which can be treated at the same time.

4.1.1 Case #1: The Eye Hit by a "Steel Bar"

4.1.1.1 Case Description

A 47-year-old man presented at the emergency room with the right eye hit by a "steel bar" 8 h ago. Visual acuity was 0.08 in the injured eye. In addition to 7:00–10:00, most of the iris root was torn and crinkled. The pupil was shapeless. The vitreous hernia could be seen in the anterior chamber (Fig. 4.2). OCT showed a lamellar hole in macular. The diagnoses were blunt injury, iridodialysis, and macular lamellar hole of the injured eye. The patient underwent suturing of iridodialysis and anterior vitrectomy.

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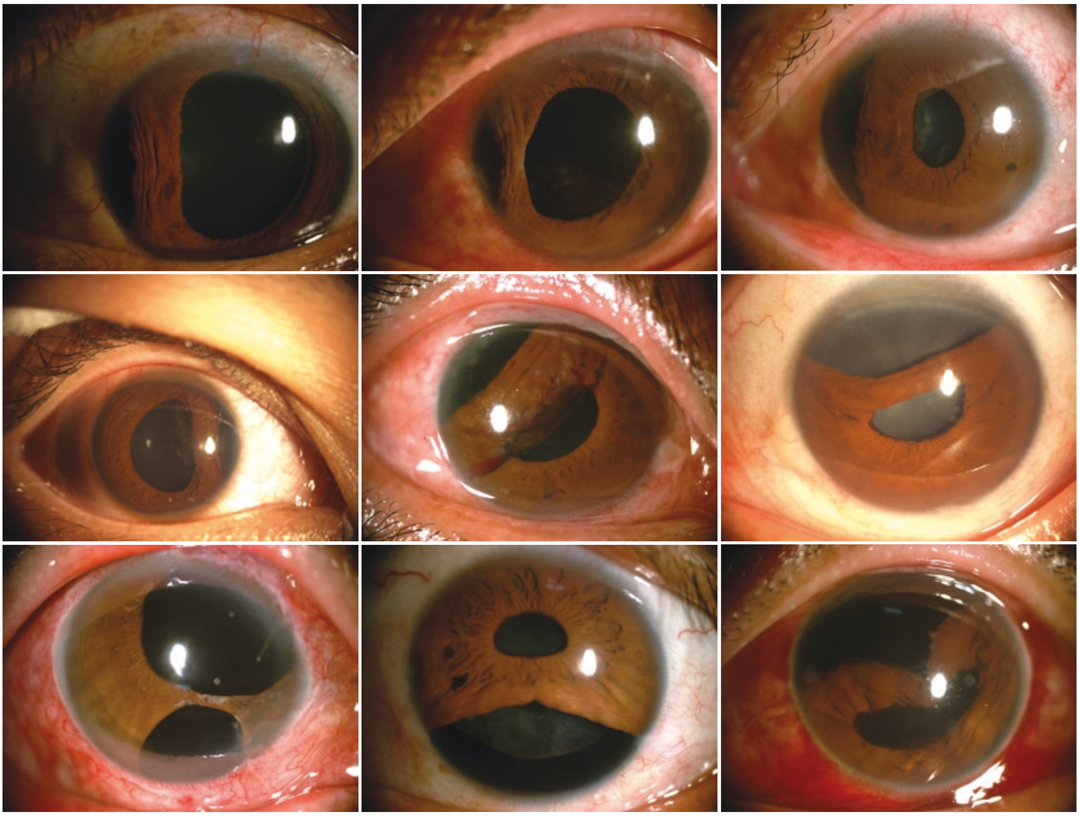

Fig. 4.1 Pupil deformation, pupil displacement, and double pupil

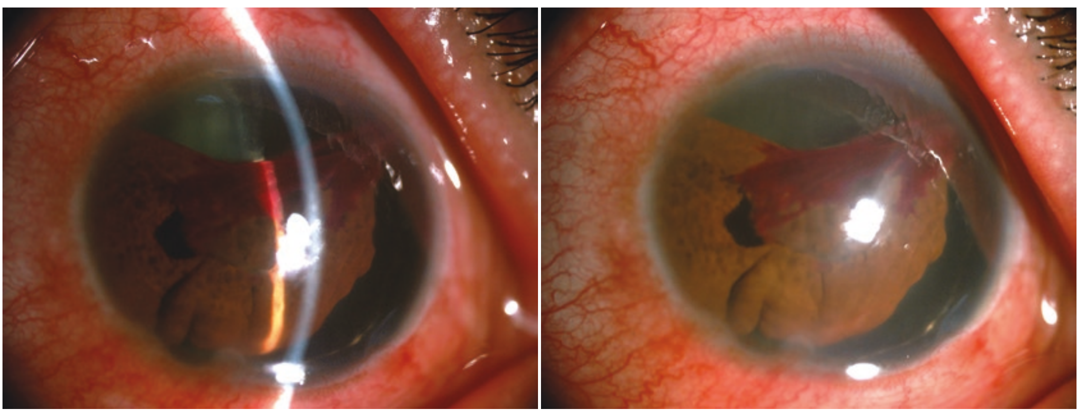

Fig. 4.2 Preoperative

After the surgery, the pupil was almost regular and circular (Fig. 4.3), and the visual acuity was improved to 0.15.

4.1.2 Case #2: The Eye Hit by a "Nail"

4.1.2.1 Case Description

A 33-year-old man presented at the emergency room with the right eye hit by a "nail" 15 h ago. Visual acuity was 0.05 in the injured eye. The iris root was torn in 6:00–9:00–10:00. The pupil was not round and the light reflection attenuated (Fig. 4.4). Funduscopy revealed slight vitreous hemorrhage. Optic disc and retina were unremarkable. Flash electroretinogram showed decreased amplitude on each wave. The diagnoses were blunt injury, iridodialysis, vitreous hemorrhage, and retinopathy of the injured eye. The patient underwent suturing of iridodialysis. After the surgery, the pupil was almost regular and circular (Fig. 4.5), but the visual acuity was not improved.

4.1.3 Case #3: The Eye Hit by a "Stone"

4.1.3.1 Case Description

A 64-year-old man presented at the emergency room with the right eye hit by a "stone" 10 h ago. Visual acuity was HM/30 cm in the injured eye.

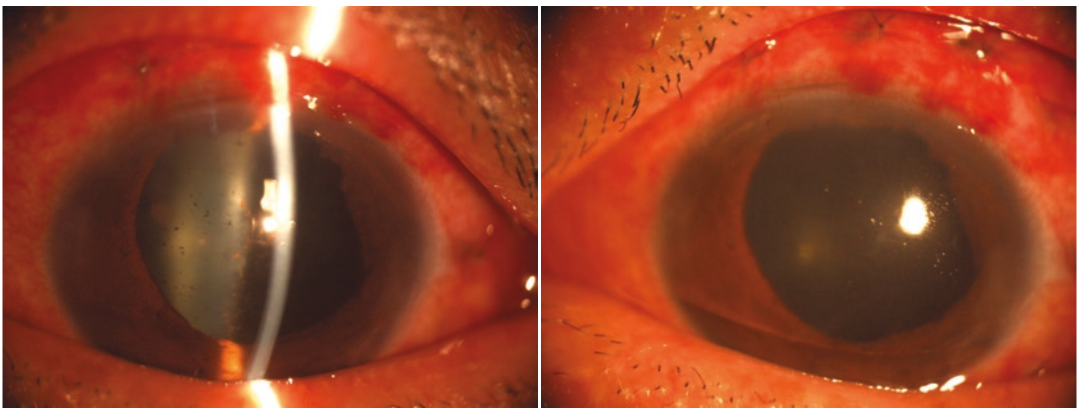

Fig. 4.3 Postoperative

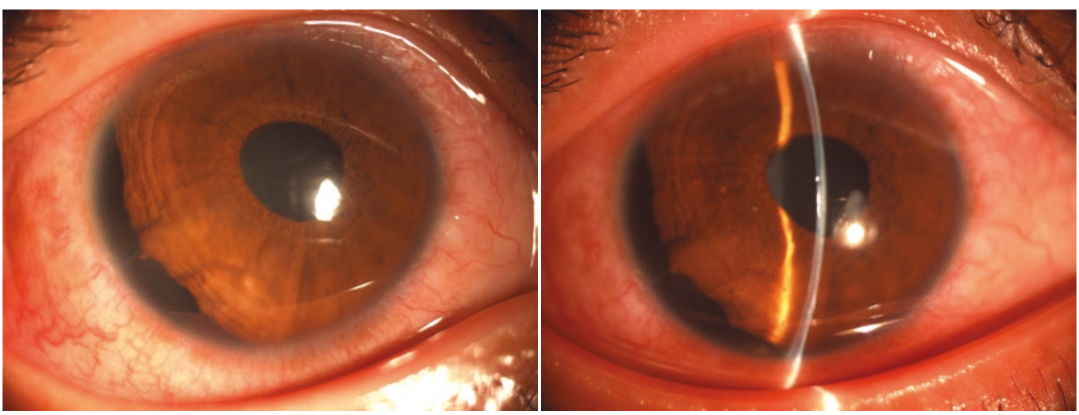

Fig. 4.4 Preoperative

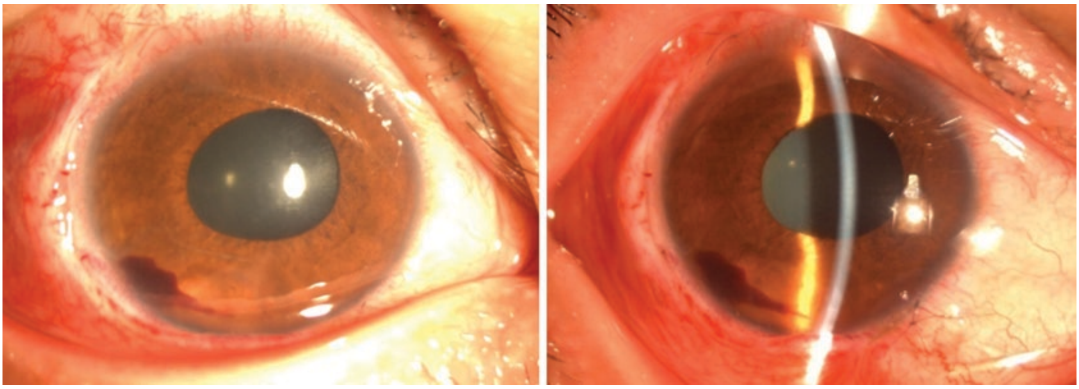

Fig. 4.5 Postoperative

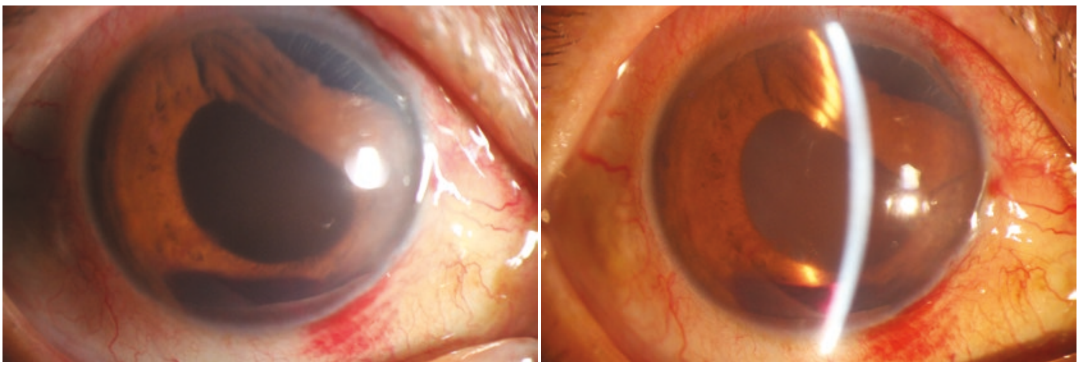

Fig. 4.6 Preoperative

The iris root was torn in 11:30–12:00–2:30. The pupil was not round with a shape of “D,” and the light reflection disappeared. The lens is absent (Fig. 4.6). Funduscopy revealed severe vitreous hemorrhage. The diagnoses were blunt injury, iridodialysis, lens dislocation, and vitreous hemorrhage of the injured eye. The patient underwent suturing of iridodialysis, lens removal, and vitrectomy. After the surgery, the pupil was almost regular and circular (Fig. 4.7), and the visual acuity was improved to 0.02.

4.1.4 Case #4: The Eye Hit by an “Explosive”

4.1.4.1 Case Description

A 23-year-old man presented at the emergency room with the right eye hit by an “explosive” 5 days ago. Visual acuity was 0.4 in the injured eye. The iris root was torn and defected in 5:00. The pupil was not round. The lens was slightly turbid (Fig. 4.8). Funduscopy revealed light reflection disappeared from macular fovea. The diagnoses were blunt injury, iridodialysis, iridocoloboma, cataract, and retinopathy of the injured eye. The patient underwent coroplasty. After the surgery, the shape of pupil almost recovered completely (Fig. 4.9), and the visual acuity was improved to 0.5.

4.1.5 Tips and Pearls

Iridodialysis often occurs in the ocular blunt injury. When the photophobia, monocular diplopia, or visual disorder is severe, it needs surgical treatment. However, if there are complications such as retinal detachment, macular hole, and traumatic optic neuropathy, even if the operation

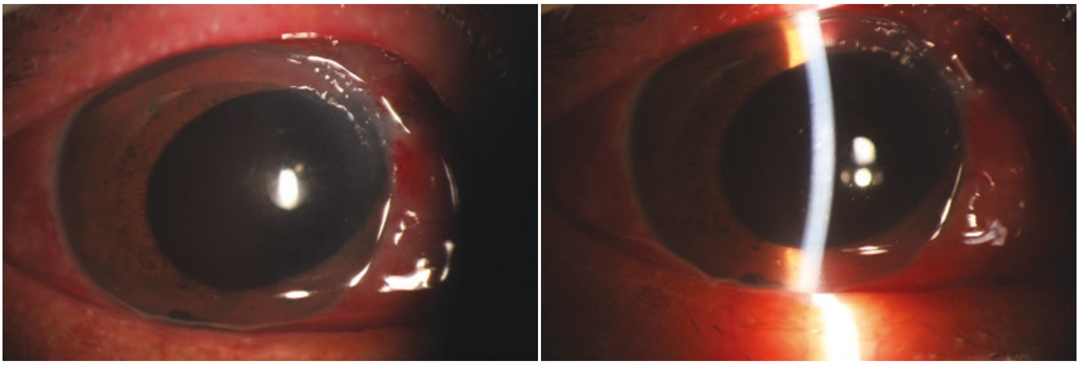

Fig. 4.7 Postoperative

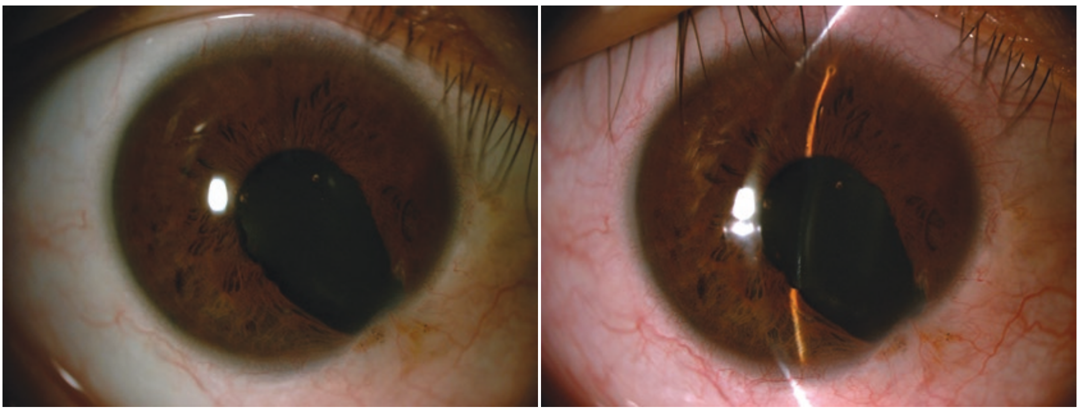

Fig. 4.8 Preoperative

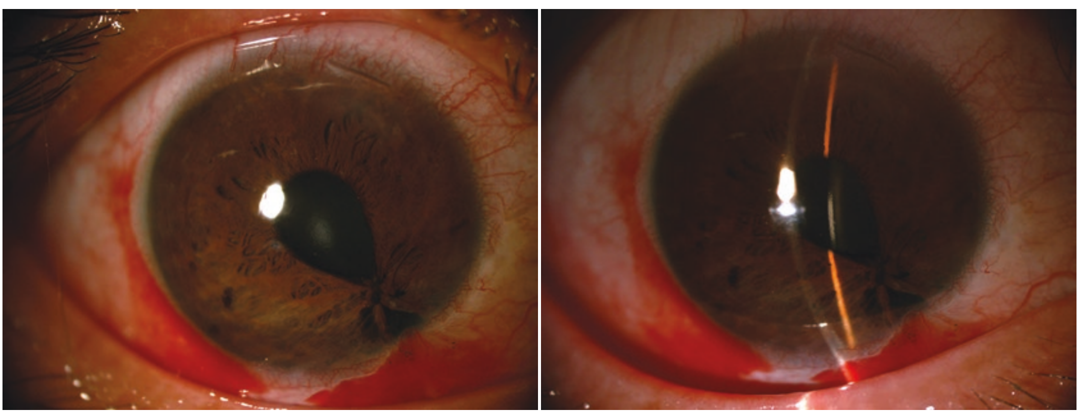

Fig. 4.9 Postoperative

is completed, the vision may also recover poorly. There are many surgical methods of iridodialysis repair, including incarceration method, simple suture of the cornea, suture of the cornea under scleral flap, etc. Each method has advantages and disadvantages. Clinical application should be based on the range of iridodialysis, the severity of synechia, the elasticity of the iris, etc.

4.2 Hyphema

4.2.1 Introduction

Hyphema is the entry of blood into the anterior chamber (AC) [1]. It frequently occurs as a result of ocular trauma and the incidence varies with injury type. Ferenc Kuhn reported that the percentage of hyphema that occurred after contusion and open globe injuries in the United States Eye Injury Registry (USEIR) were 14% and 45%, respectively [2]. Males predominate with a higher mean annual incidence than females: 20 and 4 per 100,000 population, respectively [3]. Note that a high frequency of hyphema was found in children or young adults with an incidence of approximately 2 per 10,000 children per year [4]. Nearly 2–14% of children who suffered from ocular trauma had poor visual prognoses, even blindness [5–7]. Although the blood can be absorbed totally in most cases, its secondary complications will impair visual function severely, such as glaucoma, recurrent bleeding, and corneal blood staining. Therefore, diagnosis and in time management of hyphema could help prevent the subsequent complications and finally preserve visual acuity.

The most common symptoms of hyphema are eye redness, reduced visual acuity, and eye pain [8]. It can be easily found through slit lamp. However, the detection of concomitant injuries is more difficult, especially in the setting of total hyphema. Ultrasound biomicroscopy (UBM), B ultrasound, radiological tests, and visual electrophysiology are useful to identify these associated injuries. Visual outcome mainly lies in the secondary complications of blood and coexistent posterior segment injuries (e.g., vitreous hemorrhage, retinal detachment, optic neuropathy). Due to occlusion or damage of the trabecular meshwork and peripheral anterior synechia, approximately 30% of hyphema patients exhibit increased intraocular pressure (IOP) [9]. Recurrent bleeding arises from clot lysis and retraction within the traumatized vessels and occurs at a rate of 2–38% [10]. The likelihood of high IOP and rebleeding cannot be predicted accurately by the size of hyphema, especially in the patients with sickle cell disease [10–14]. The incidence of corneal bloodstaining varies from 2 to 11% [15–17] and the risk factors include endothelial dysfunction, total hyphema, and elevated IOP. It also can occur in patients with endothelial damage but subtotal hyphema and normal IOP [18, 19]. The rate of coexistent posterior abnormalities reached 53–61% in hyphema eyes [2]. Conservative treatments include bed rest, topical cycloplegics, steroids, aminocaproic acid, antifibrinolytic agents, and lower IOP treatment. Surgical managements are advocated when blood fails to absorb, IOP cannot be medically controlled, or corneal bloodstaining occurs.

4.2.2 Case #1: Hyphema with Conservative Treatment

4.2.2.1 Case Description

A 51-year-old male patient reported a blunt-force trauma to the left eye followed by a sudden diminution of vision for 6 days. His presenting visual acuity (VA) of the affected eye was light perception. Slit-lamp examination showed corneal edema and a large amount of blood in the AC. Lens, vitreous body, and fundus were invisible (Fig. 4.10). IOP was 10 mmHg by noncontact tonometer (NCT). UBM demonstrated the blood filled in the AC and segmental cyclodialysis cleft (Fig. 4.11). B

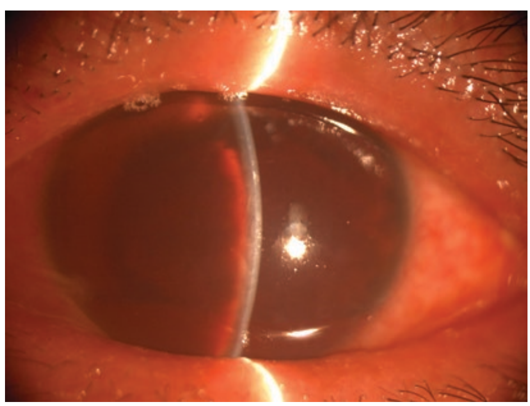

Fig. 4.10 Slit-lamp photograph of left eye demonstrating hyphema accounting for nearly 2/3 AC

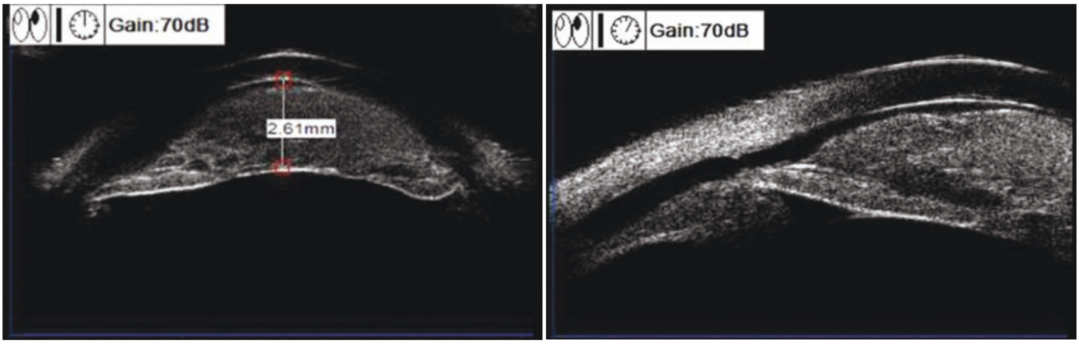

Fig. 4.11 UBM images showed the AC was filled with blood (left) and cyclodialysis cleft ranged from 12 o'clock to 3 o'clock position (right)

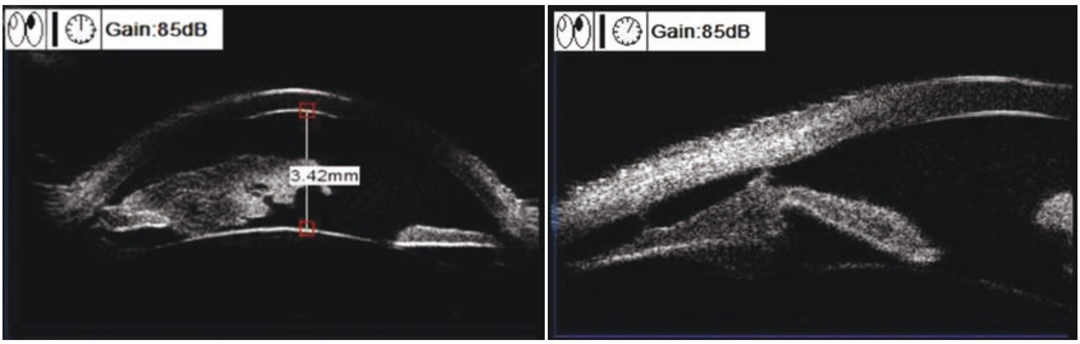

Fig. 4.12 On follow-up at 10 days, UBM images showed the blood was markedly absorbed (left) and cyclodialysis cleft was improved (right)

ultrasound showed vitreous opacity and choroidal detachment (Fig. 4.14 left). So the diagnosis of the left eye should be ocular blunt trauma, hyphema, cyclodialysis cleft, vitreous hemorrhage, and choroidal detachment. Medical and complementary treatments were adopted to accelerate blood absorption. During the 35-day follow-up period, the best-corrected visual acuity (BCVA) of the left eye increased to 0.1 and IOP was normal. UBM and B ultrasound revealed gradually reduced blood and the improvement in the cyclodialysis cleft and choroidal detachment (Figs. 4.12, 4.13, and 4.14).

4.2.2.2 Tips and Pearls

In the setting of a large hyphema volume, a normal IOP should alert the possibility of other intraocular injuries, such as cyclodialysis cleft and choroidal detachment. If the other intraocular injuries are not serious and IOP is normal or slightly abnormal, conservative treatment is also suited for the patient with a large hyphema volume. During the routine follow-up, IOP, UBM, and ultrasonography are important to monitor the changes of disease.

4.2.3 Case #2: Hyphema and Corneal Blood Staining

4.2.3.1 Case Description

A 42-year-old male patient crashed into a railing and then presented with sudden vision loss in the right eye for 6 h. His VA of the affected eye was no light perception (NLP). On day 7 after careful suture of sclera, the VA of the right eye was also NLP. Slit-lamp examination showed red-brown blood fully filled in the AC and central and superior blood corneal staining. Other intraocular structures were invisible (Fig. 4.15). IOP was

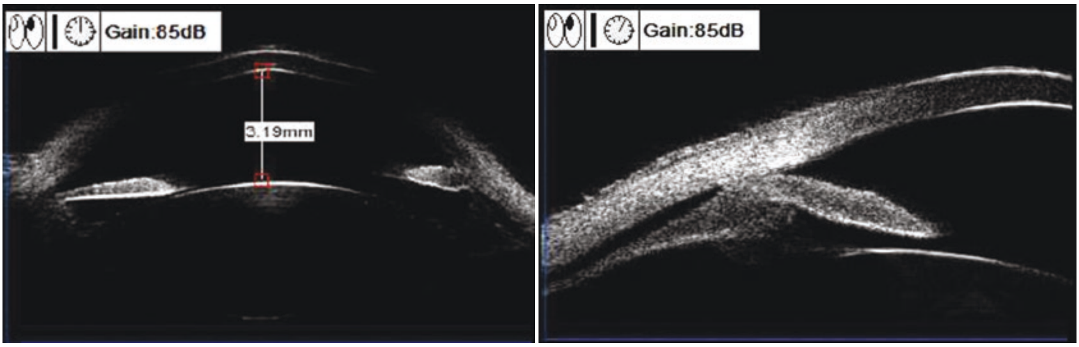

Fig. 4.13 On follow-up at 35 days, UBM images showed the blood was totally absorbed (left) and ciliary body partially reattached (right)

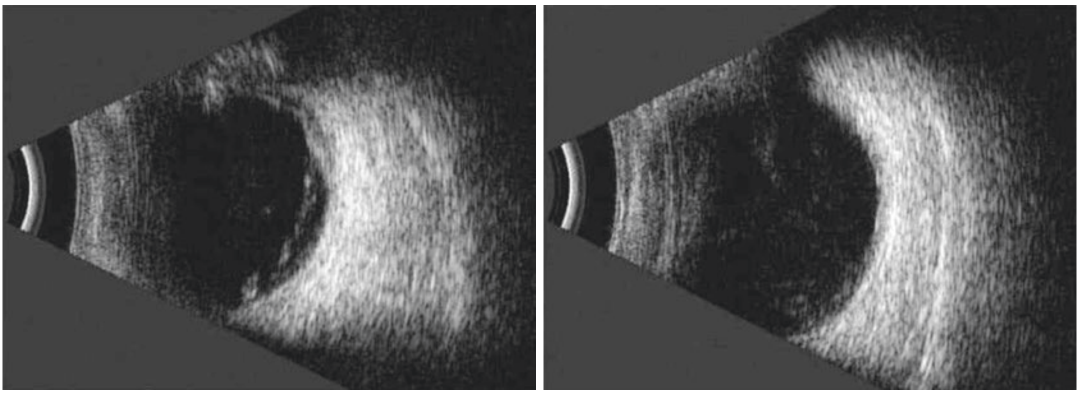

Fig. 4.14 B ultrasound demonstrated vitreous opacity and segmental choroidal detachment (left). On follow-up at 35 days, both of them improved (right)

7 mmHg by NCT. Corneal endothelial cells could not be counted. B ultrasound revealed severe vitreous hemorrhage and retinal detachment (Fig. 4.16). Flash visual evoked potential (FVEP) showed P2 wave turned off which implied the nonfunctional optic nerve (Fig. 4.17). So the diagnosis of the right eye should be corneal blood staining, hyphema, vitreous hemorrhage, retinal detachment, and blindness. Based on the above, vitreoretinal surgery should be performed to preserve his eyeball. However, the patient refused it due to personal reasons.

4.2.3.2 Tips and Pearls

Corneal blood staining can occur in patients with dysfunctional endothelium and total hyphema but low IOP. Visual electrophysiology is helpful to better understand the function of optic nerve and predict the treatment outcome. Surgical intervention should be performed immediately when corneal blood staining threatens.

4.2.4 Case #3: Hyphema and Recurrent Bleeding

4.2.4.1 Case Description

A 43-year-old male patient presented with sudden vision loss in the right eye for the last 15 days after he fell down. The VA of the affected eye was hand motions at 10 cm. Slit-lamp examination showed a layer of blood with a height of 2 mm and vitreous hemorrhage (Fig. 4.18 left). Fundus was invisible. IOP was 8 mmHg by NCT. UBM demonstrated the hyphema and lens subluxation (Fig. 4.19 left). B ultrasound confirmed vitreous hemorrhage (Fig. 4.19 right). FVEP showed P2 wave was delayed and its

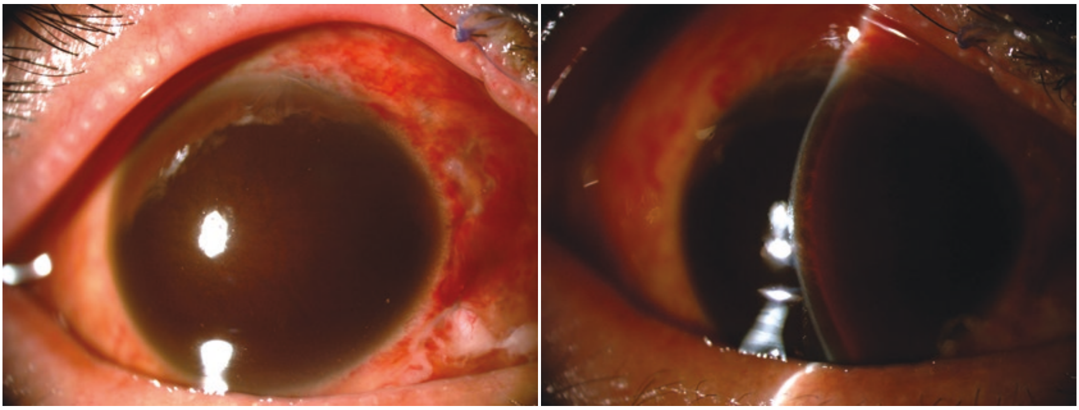

Fig. 4.15 Slit-lamp photograph of right eye showed red-brown blood fully filled in the AC (left) and brownish discoloration of the central and superior corneal stroma (right)

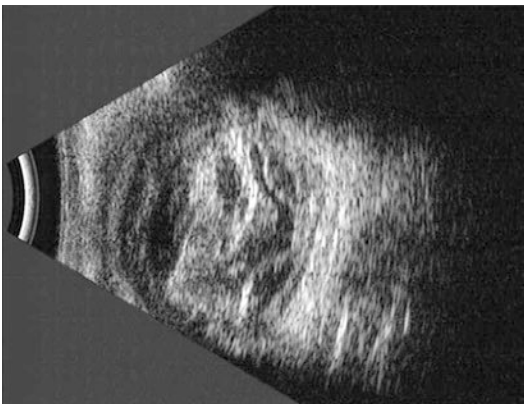

Fig. 4.16 B ultrasound demonstrated severe vitreous hemorrhage and retinal detachment

amplitude decreased. So the diagnosis of the right eye should be hyphema, lens subluxation, vitreous hemorrhage, and traumatic optic neuropathy. Conservative treatments were adopted and the height of blood in the AC decreased to 1 mm (Fig. 4.18 right). However, total hyphema which implied the occurrence of recurrent bleeding was found after 5 days (Fig. 4.20), and then the lensectomy-vitrectomy combined with silicone oil injection was performed. During the procedure, a large amount of blood was dispersed in the vitreous cavity. Retinal detachment caused by the traction of retinal scar was found, and it may be the main reason of recurrent bleeding. After the surgery, no active bleeding was found (Fig. 4.21).

4.2.4.2 Tips and Pearls

To the patients with lens subluxation, recurrent bleeding may be a signal of the aggravation of posterior segment lesions. The traction of fibrosis tissue surrounding the retina wound increases the incidence of retinal detachment and recurrent bleeding. Active treatment, especially vitrectomy, is needed to reduce the complication rate of recurrent bleeding.

4.3 Iris Foreign Body

4.3.1 Introduction

Foreign bodies in the eye can be small specks of dirt or eyelashes or larger objects such as cinders, rust, or glass. The eye is damaged easily. Intraocular foreign body (IOFB) injuries vary in presentation, outcome, and prognosis depending upon various factors. Iris foreign body, as the name implies, is located on the iris. The isolated iris foreign body occurs rarely; it is often injured concurrently with the cornea, lens, or ciliary body. Increased awareness about eye protection, improved surgical techniques, and advancements in bioengineering are responsible for an improved outcome in injuries with IOFB. The limiting factor is still the extent of the initial injury. Iris foreign body is intraocular foreign body embedded on the iris. Metallic and magnetic IOFBs are the most common. The iris is the colored part of your eye around the pupil. When the iris is injured, it

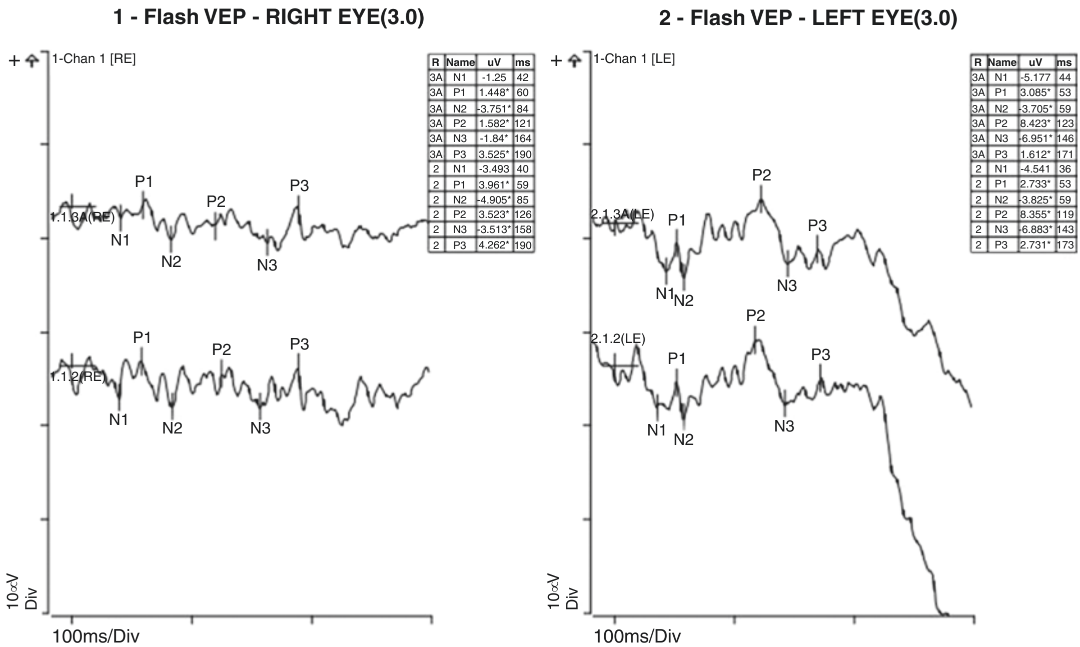

Fig. 4.17 FVEP showed P2 wave turned off in his right eye which signaled serious damage of optic nerve and poor visual prognosis

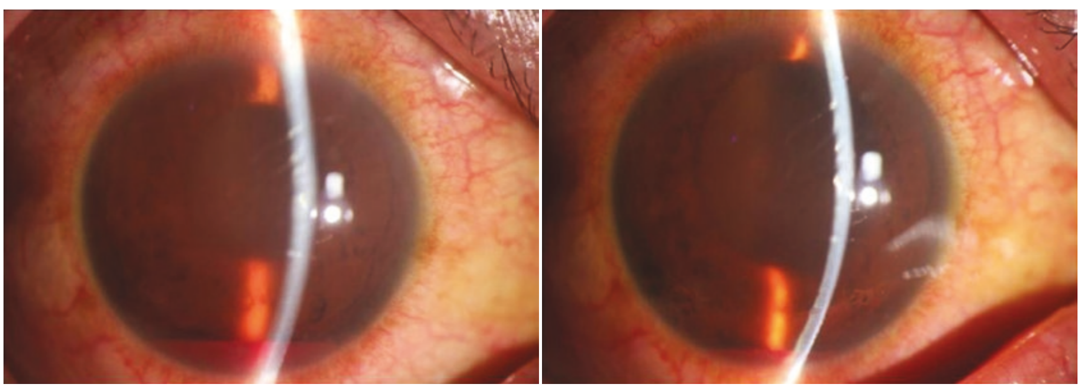

Fig. 4.18 Slit-lamp photograph of right eye showed corneal transparent with Descemet's membrane folds, a layer of blood with a height of 2 mm, dilated pupil with disappeared direct light reflex, and vitreous hemorrhage (*left*). After 4 days, the height of blood in the AC decreased to 1 mm (*right*)

may no longer be able to open and close properly in response to light.

4.3.2 Case: Nail on the Iris

4.3.2.1 Case Description

A 55-year-old male patient complained that an iron nail dropped into his right eye when he worked. His presenting VA of the affected eye was 10/25. Slit-lamp examination showed the entrance on the cornea was closed and mild edema, an iron nail was located on the surface of iris (Fig. 4.22a), and lens, vitreous body, and fundus were unremarkable. IOP was 7 mmHg by NCT. B scan showed a little bit of vitreous opacity (Fig. 4.22b).

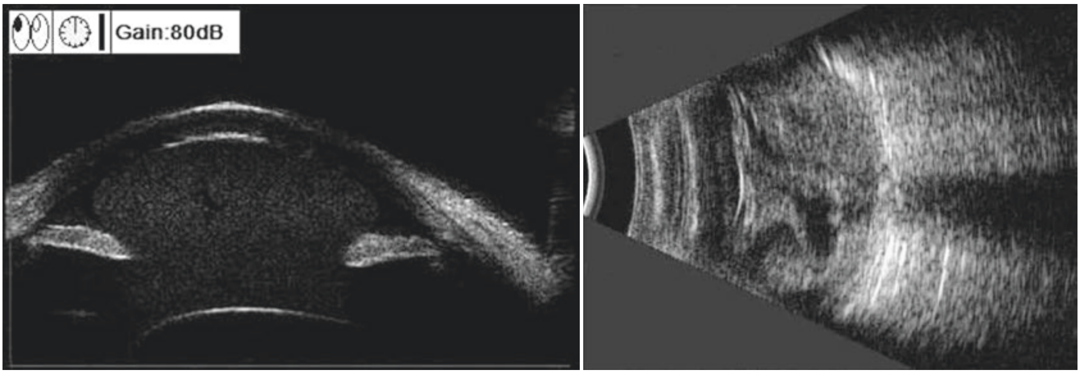

Fig. 4.19 UBM images demonstrated the hyphema and lens subluxation (*left*). B ultrasound showed vitreous hemorrhage without retinal detachment (*right*)

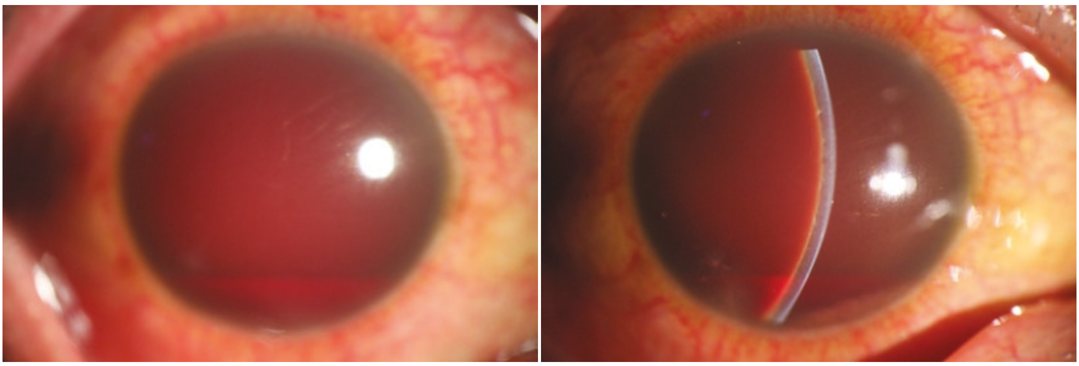

Fig. 4.20 Slit-lamp photograph of right eye showed the blood fully filled in the AC, and other intraocular structures were invisible after 5 days

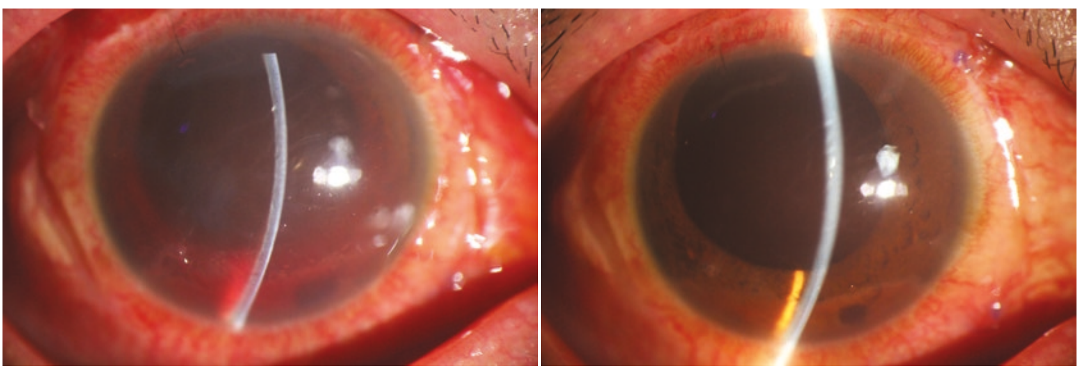

Fig. 4.21 On day 3 post-surgery, a small amount of blood in the AC was found (*left*), and it was totally absorbed 1 week later (*right*)

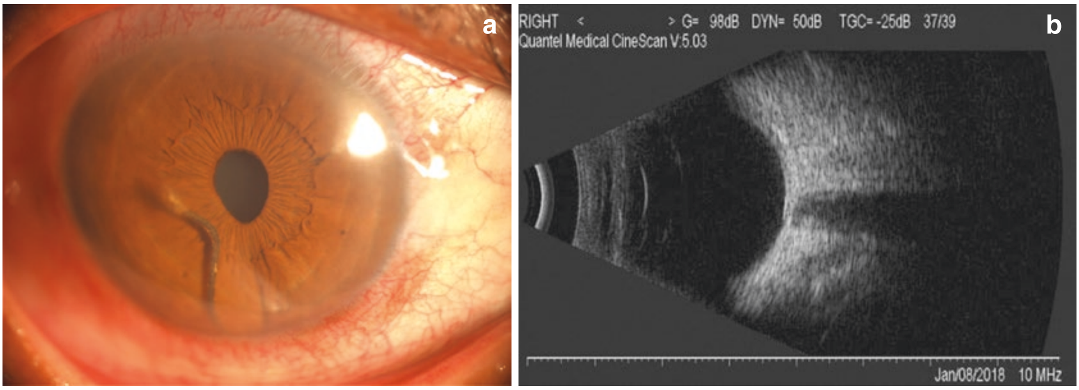

Fig. 4.22 (**a**) Slit-lamp photograph before surgery. (**b**) B scan image before surgery

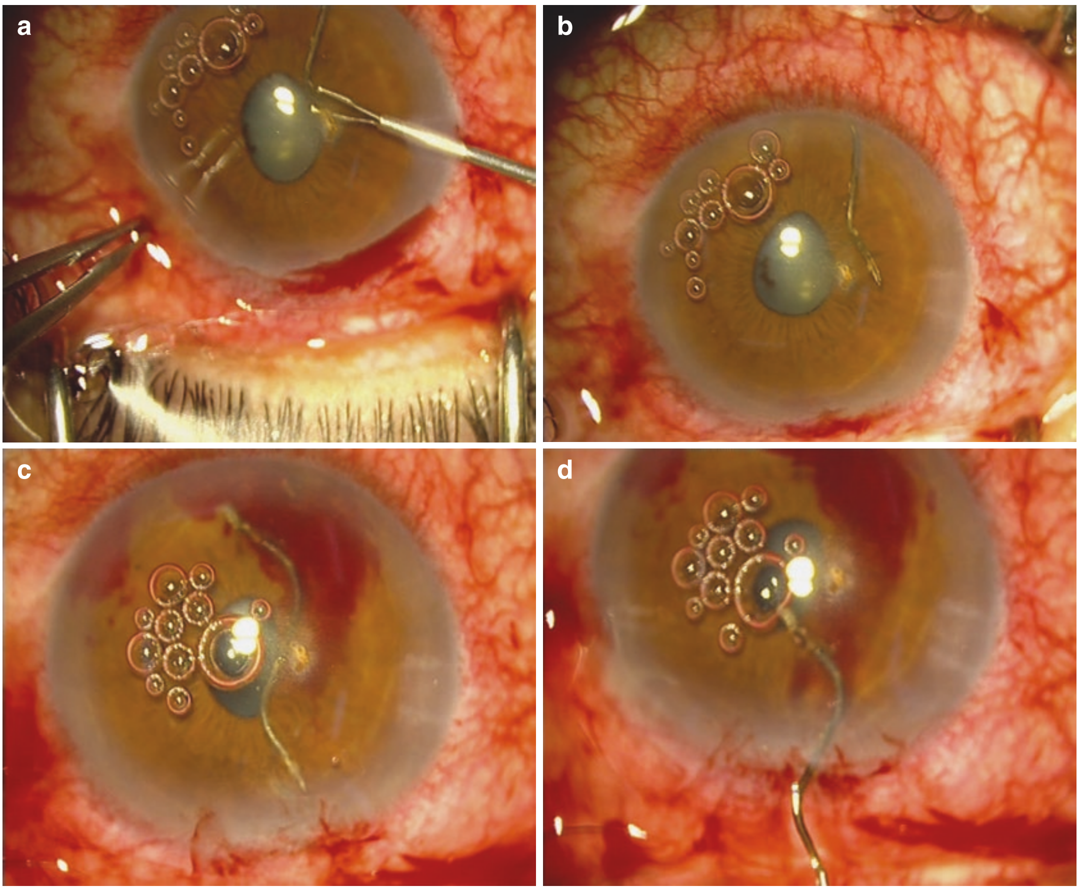

Fig. 4.23 (**a**–**d**) Surgical procedures

4.3.2.2 Surgical Procedures

During the surgery, the metallic IOFB was seen on the surface of iris, the length was 7 mm approximately, the head of IOFB was inserted into corneal endothelium, and the end of IOFB was embedded into the iris. First, the head was put into anterior chamber (Fig. 4.23a, b), then the end of IOFB was dissociated from the iris

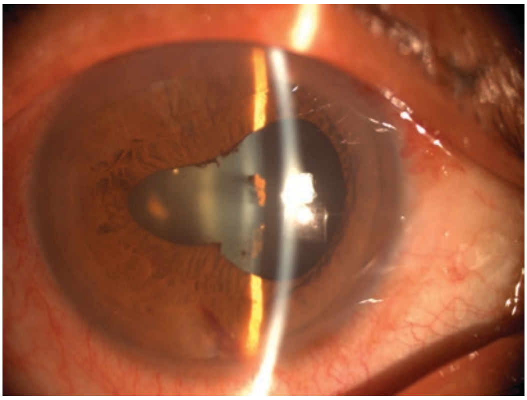

Fig. 4.24 Slit-lamp photograph 1 week after surgery (the pupil was mydriatic)

(Fig. 4.23c), and the whole IOFB was pulled out through the superior transparent cornea incision (Fig. 4.23d). During the surgery, the healon was necessary to protect cornea. The surgical complication was slight hyphema.

4.3.2.3 Follow-Up

The patient was treated with antibiotic and steroidal eye drop for 1 week (Fig. 4.24); the visual acuity of right eye was 5/25 when he discharged from the hospital.

4.3.2.4 Tips and Pearls

Care should be taken while removing the foreign bodies to avoid any injury to surrounding tissue. It is considered that when the foreign bodies penetrates the cornea, they should be withdrawn along the track of entry, while if the corneal wound was closed, they had to be extracted anteriorly through limbal sections by means of the hand magnet. Personal experience or matters need attention.

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5 Lens Injury

Haibo Li

Abstract

Any mechanical or physical force that caused the crystalline lens position, stability, clarity, and capsular integrity to change is called lens injury. The mechanical forces include contused cataract, subluxation and dislocation (anteriorly into the anterior chamber or posteriorly into the vitreous cavity), perforation and penetrating injury, and intralenticular foreign bodies (siderosis bulbi, chalcosis, etc.). The physical forces include radiation (ionizing radiation, infrared radiation, ultraviolet radiation, microwave radiation, etc.), chemical injury, and electrical injury.

Lens injury demographically affects patients of all ages, with 53% of patients falling between 7 and 30 years of age. Male patients are four times more often affected than female patients (Lamkin et al., Am J Ophthalmol 113:626–631, 1992).

Sometimes contused cataract and lens dislocation occurred simultaneously in one eye. Lens injuries often combined with anterior and posterior segment injuries, such as cornea contusion, hyphema, traumatic glaucoma, iridodialysis cleft, mydriasis, cyclodialysis cleft, vitreous hemorrhage, retinal detachment, choroidal detachment, etc.

The treatment for lens injury is either medical or surgical, based on patient's symptoms, needs, and expectations. Few mild subluxation or intralenticular foreign body composed of nonferric or non-cupric material which does not affect the vision can be managed conservatively by careful observation. Most of lens injuries, like other forms of crystalline lens pathology, require surgical intervention. The mode of surgical varies individually. Surgical extraction is the most common method. Whether the intraocular lens can be implanted or not at the meantime mainly depends on the retinal conditions. Besides, other tissues injured together also need intervention. Combined surgery was a good choice to cure other complications. Most cases had a good vision after intervention, while few patients got poor prognosis due to fundus irreversible injury.

Keywords

Lens injury · Contused cataract · Subluxation and dislocation · Perforation and penetrating injury · Siderosis bulbi

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5.1 Contused Cataract

5.1.1 Introduction

Contused cataract often occurred in a blunt, non-perforating eye injury. It may involve only a small portion of the lens or the entire lens. Vossius ring (a brown ring of pigment on the anterior lens capsule resulting from forceful iridolenticular contact) is visually in early stage of trauma, but not significant in some cases [1].

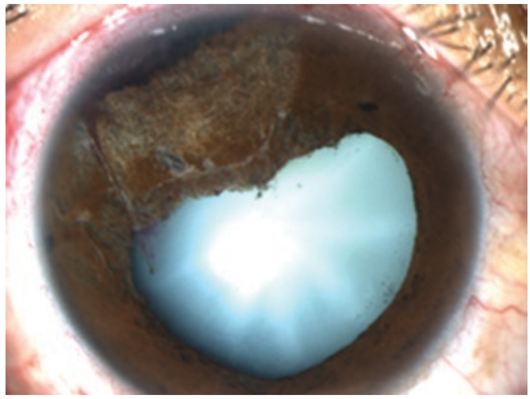

Fig. 5.1 Slit-lamp image of the right eye showed opacification of the whole lens, atrophy of iris, iridodialysis cleft at 10:00–12:00, and mydriasis before operation

5.1.2 Case: The Contused Cataract Induced by a Piece of Stone

5.1.2.1 Case Description

A 54-year-old male presented to the outpatient room with poor vision to his right eye. He got stone injury to his right eye 2 months ago while hammering a stone at workplace without any protective glasses. His left eye was normal. The best corrected vision of right eye decreased to hand movement/40 cm, and the IOP was 13.4 mmHg. Slit-lamp photograph showed opacification of lens cortex, atrophy of iris, iridodialysis cleft at 10:00–12:00, and mydriasis (Fig. 5.1). B-scan ultrasonography showed high reflection of lens cortex, clear vitreous body, and stable fundus (Fig. 5.2). UBM showed iridodialysis cleft and vitreous prolapse in upper temporal angle (Fig. 5.3). Routine phacoemulsification and IOL implantation were performed under retrobulbar anesthesia as well as iridodialysis cleft repairing and coreoplasty. He got uncorrected visual acuity of 0.8 1 week after surgery, and the pupil became almost round (Fig. 5.4). The best corrected vision of the right eye improved to 1.0 at the last visit 3 months later.

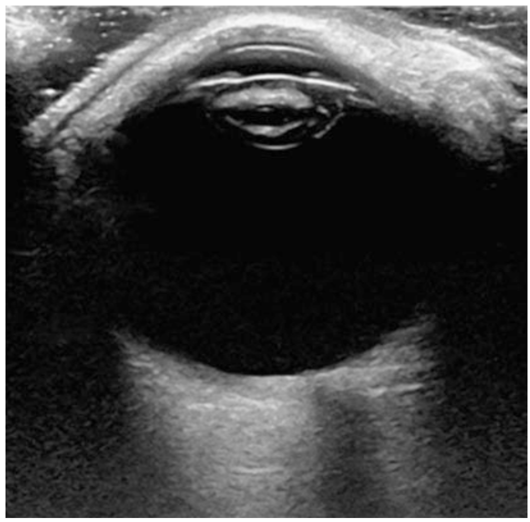

Fig. 5.2 B-scan ultrasonography showed high reflection of lens cortex, clear vitreous body, and stable fundus before operation

5.1.2.2 Tips and Pearls

In the early stage of contused cataract, it involved only small portion of lens cortex; patient got good vision when the opacification was beyond the vision axis. Conservative observation was recommended. If it affected the vision seriously, surgery removal of contused cataract was recommended. It developed to entire lens opacification quickly in elder patients while slowly in younger ones. If the contused cataract wasn't accompanied with anterior and posterior segment injuries, routine phacoemulsification and IOL implantation were recommended. But more attention should be taken on lens zonular fibers and lens capsule. Many cases got mild subluxation. Anterior lens capsule was fragile due to swollen lens cortex, which wasn't easy to make a standard continuous curvilinear capsulorhexis. Posterior lens capsule was also fragile and easily ruptured particular in high perfusion pressure. Therefore anterior

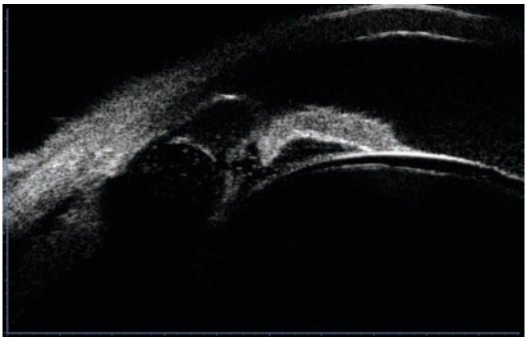

Fig. 5.3 UBM showed iridodialysis cleft and vitreous prolapse in upper temporal angle before operation

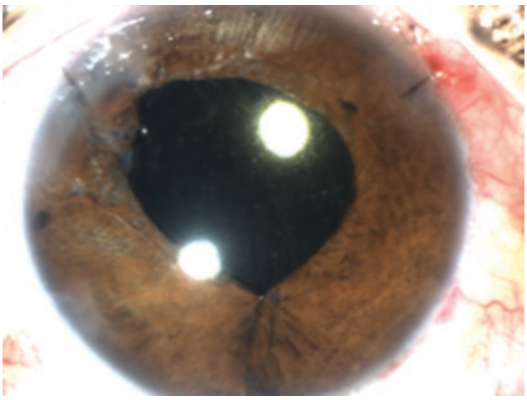

Fig. 5.4 Slit-lamp photo 1 week after operation showed clear cornea, stable anterior chamber, centered IOL, sutured iridodialysis cleft, and coreoplasty at 6 o'clock

segment vitrectomy was needed when posterior lens capsule ruptured and vitreous prolapsed into anterior chamber. Vision may improve after removal of the cataract and IOL implantation.

5.2 Subluxation and Dislocation

5.2.1 Introduction

When there is a blunt trauma or rupture to the eyeball, transient shortening of the eye in the anteroposterior direction can disrupt the zonular fibers of the lens, causing subluxation or dislocation of the lens. In a similar manner, perforating and penetrating injury of the eye also can damage the zonules directly or indirectly [2]. The lens may be dislocated in any direction, beyond the visual axial. With strong forces, the whole lens may drop into anterior chamber or vitreous cavity and also run out of the eyeball into conjuntival sac in rare cases. In some cases, blunt trauma causes both dislocation and cataract formation.

Symptoms of lens subluxation and dislocation include decreased uncorrected vision (including hyperopic or myopic shift), monocular diplopia, glare, astigmatism, and functional aphakia.

There are a wide range of surgery methods for lens subluxation or dislocation, while routine phacoemulsification techniques weren't suitable for particular cases with weak zonular support. To enhance the stability of capsular bag, there are a lot of capsular support devices available used nowadays—capsular tension rings (CTRs), modified CTRs (M-CTRs), capsular tension segments (CTSs), and capsular support hooks [3]. With their help, lens posterior capsule may be carefully preserved, blocking vitreous body into anterior chamber, and then intraocular lens can be easily placed intracapsular or in the sulcus.

5.2.2 Case #1: Anterior Chamber Lens Subluxation Caused by a Wood

5.2.2.1 Case Description

A healthy 61-year-old woman presented with ocular pain and sharply decreased vision in her left eye while hammering a wood at workplace 4 h ago. On examination, her right eye was normal. Her best corrected vision in left eye was 0.05, and the IOP was 34 mmHg. Slit-lamp photograph showed the inferior and temporal parts of the lens dropped into anterior chamber which induced the pupil irregularly. Inferior anterior chamber became narrow, and inferior local cornea appeared mildly edema (Fig. 5.5). Anterior segment optical coherence tomography revealed the subluxated lens contacting with the cornea endothelia and narrow anterior chamber (Fig. 5.6). Emergency removal of the subluxated lens was performed due to pupil block glaucoma. The whole lens subluxated into anterior chamber when pupil dilated (Fig. 5.7). An 8-mm scleral tunnel incision was made at superior side, and the

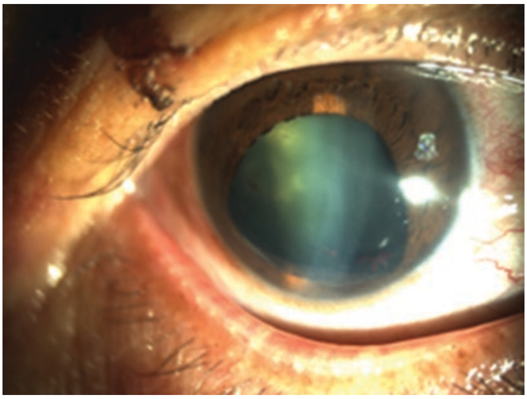

Fig. 5.5 Slit-lamp photograph showed the inferior and temporal part of the lens dropped into anterior chamber which induced the pupil irregularly before operation

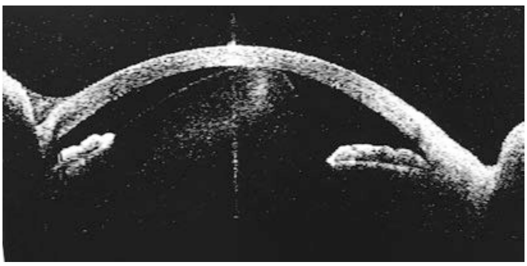

Fig. 5.6 Anterior segment optical coherence tomography revealed the subluxated lens contacting with the cornea endothelia before operation

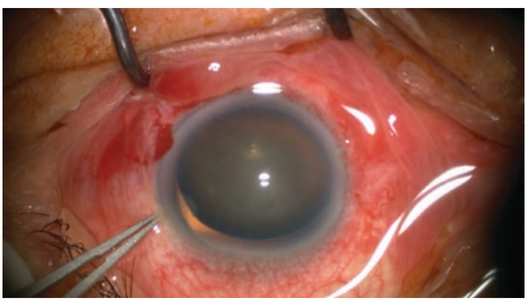

Fig. 5.7 The screenshot of the right eye during operation. The whole lens subluxated into anterior chamber when pupil dilated

whole lens was extracted carefully with lens spoon (Fig. 5.8). After closing the incision with 10-0 nylon suture, herniated vitreous was cut by a vitreous cutter (Fig. 5.9). The intraocular lens scleral fixation was performed 3 months later

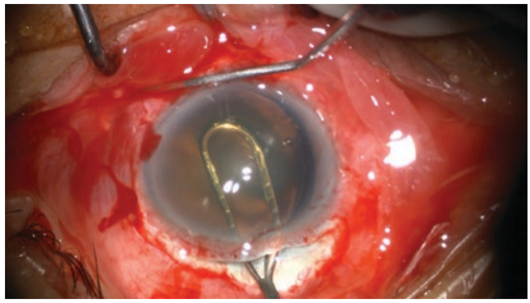

Fig. 5.8 The screenshot of the right eye during operation. An 8-mm scleral tunnel incision was made at superior side, and the whole lens was extracted with lens spoon

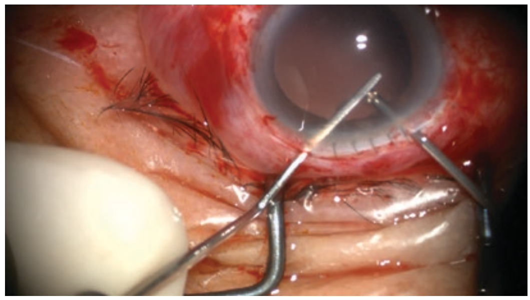

Fig. 5.9 The screenshot of the right eye during operation. Herniated vitreous was cut by a vitreous cutter through limbal incision after subluxated lens removal

when the IOP became stable. The vision improved to 0.8 at the last follow-up visit 4 months later.

5.2.2.2 Tips and Pearls

Subluxated lens into anterior chamber is usually accompanied with enlarged pupil, high IOP, and progressive cornea edema due to the pupil block. Thus emergency removal of the subluxated lens must be considered. Lensectomy and anterior segment vitrectomy through limbal or scleral incision are minimal methods, but it's harmful to the cornea endothelia. Few lens cortexes may be easily dropped into vitreous body during lensectomy. If the cortex is dropped into posterior segment, complete PPV should be done. ICCE is a classic method but large incision, which may decrease the IOP sharply and carries the risk of vitreous loss and expulsive choroidal hemorrhage. So suitable IOP is crucial during the ICCE

surgery. Using mannitol half an hour ago before operation may decrease the IOP. Also sustained Healon supplement may maintain the anterior chamber and keep IOP stable during operation. IOL implantation wasn't recommended at the early stage due to high IOP. Most IOP would return to normal range with antiglaucoma eye drop for 1 month. Few cases need glaucoma filtering operation.

5.2.3 Case #2: Mild Lens Subluxation Induced by a Stone

5.2.3.1 Case Description

A 36-year-old man presented to our eye clinic with vision loss developed for 2 years. He got a history of ocular trauma to his right eye 10 years ago when hammering a stone. On examination, his best corrected vision in the right eye was 0.15. Slit-lamp photograph showed opacification and subluxated lens in superior temporal direction after pharmacological pupil dilatation (Fig. 5.10). UBM showed discontinued zonules and dislocated lens equator (Fig. 5.11). Flexible iris hooks (iris retractors) were used to enhance intraoperative stability of the capsular bag after capsulorhexis (Fig. 5.12). Standard capsular tension rings were carefully placed in the bag with an injector (Fig. 5.13). A foldable IOL was placed in the bag (Fig. 5.14). Pupil was contracted to normal size after injecting carbachol into anterior chamber (Fig. 5.15). The patient got vision of 0.9 on first day after operation.

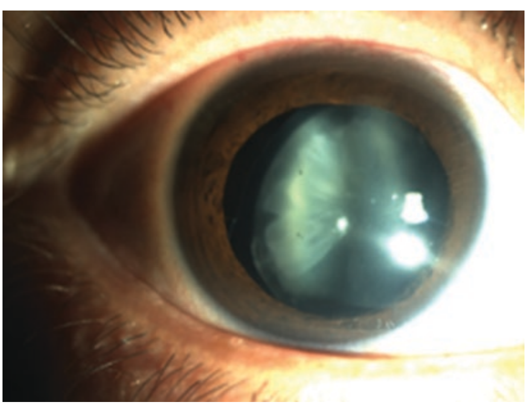

Fig. 5.10 Slit-lamp photograph showing cortex opacification and subluxated lens after pupil dilatation

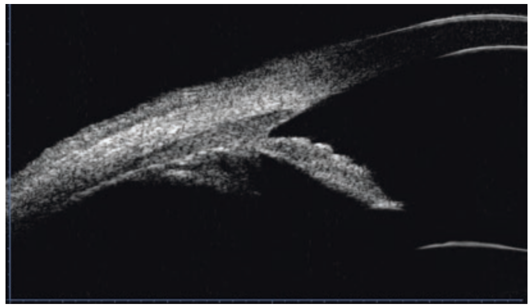

Fig. 5.11 UBM showed discontinued zonules, dislocated lens equator, and open anterior chamber angle

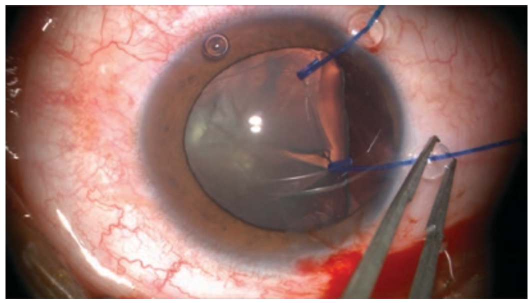

Fig. 5.12 The screenshot of the right eye during operation. Flexible iris hooks were used to enhance intraoperative stability of the capsular bag after capsulorhexis

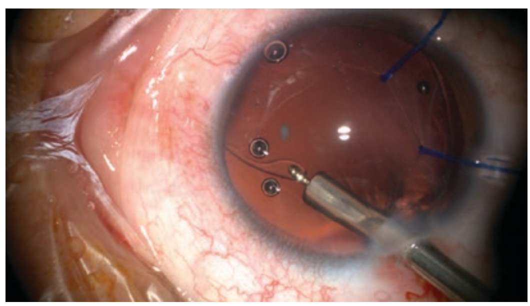

Fig. 5.13 The screenshot of the right eye during operation. The opacification was completely removed, and the standard capsular tension rings were carefully placed in the bag with an injector

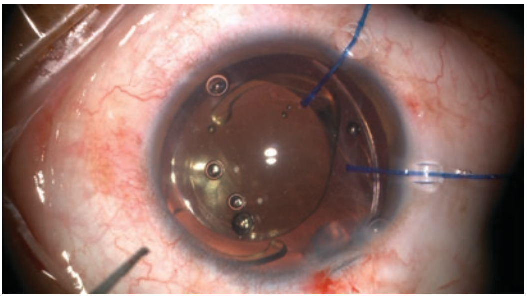

Fig. 5.14 The screenshot of the right eye during operation. The foldable IOL was placed in the bag through cornea incision

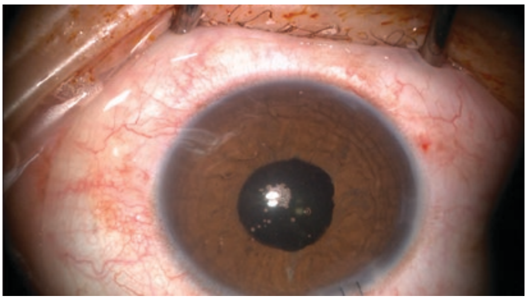

Fig. 5.15 The screenshot of the right eye at the end of operation. Pupil was returned to normal size after injecting carbachol into anterior chamber and the IOL centered well

5.2.3.2 Tips and Pearls

Mildly and moderately subluxed lenses, which are less than 180° of zonular compromise, can be successfully removed by the cataract surgeon under the help of capsular support devices. Capsular support devices, such as CTS and CTR, may be used to allow posterior chamber IOL to be placed in the bag or the ciliary sulcus successfully [4, 5]. But it is difficult to perform a round capsulorhexis due to the discontinued zonules. Too many Healon injections may aggravate the subluxated lens. Flexible iris hooks were placed at the serious subluxated position before lens removal.

5.2.4 Case #3: Lens Dislocated into Vitreous Cavity Caused by Firewood

5.2.4.1 Case Description

A healthy 56-year-old man presented to eye clinic with sharply decreasing vision of his right eye. He got blunt trauma to his right eye when cutting the firewood 1 week ago. On examination, his best corrected vision in the right eye was 0.15. Slit-lamp photograph showed vitreous prolapse and few pigment in anterior chamber after the pupil dilated (Fig. 5.16). The whole lens dropped into vitreous cavity with slit-lamp forward moving (Fig. 5.17). Optomap plus photo also showed the lens dropped into lower part of vitreous cavity (Fig. 5.18). UBM confirmed vitreous prolapse and few pigment in anterior chamber without any lens reflection (Fig. 5.19). The whole lens dropped into vitreous cavity vertically under B-scan ultrasonography (Fig. 5.20). Combined pars plana lensectomy and vitrectomy was performed under retrobulbar anesthesia (Fig. 5.21). A small hole was found in inferior temporal ora serrata during surgery. So a fluid-gas exchange was performed in the end. The gas-fluid interface was easily

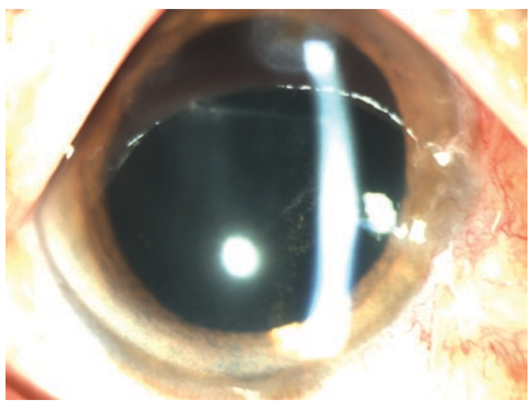

Fig. 5.16 Slit-lamp photograph of the right eye showed vitreous prolapse and few pigment in anterior chamber after the pupil dilated

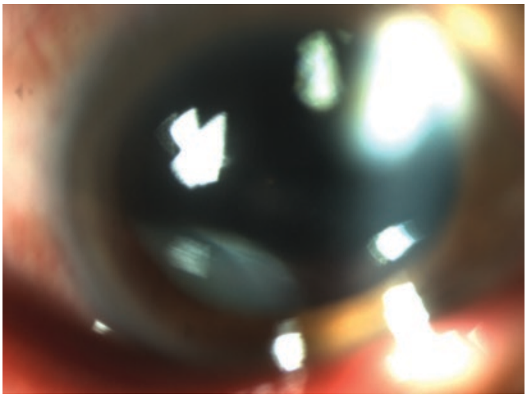

Fig. 5.17 Slit-lamp photograph of the right eye showed the whole lens drop into vitreous cavity when slit-lamp handle was moving forward

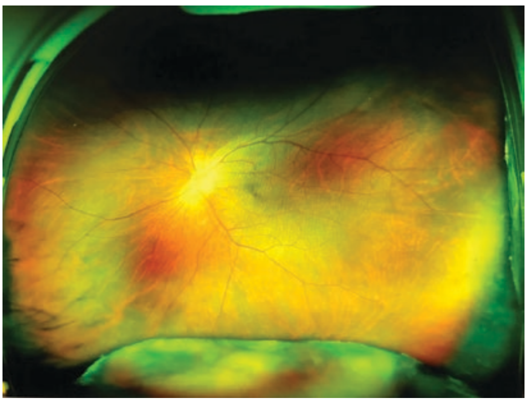

Fig. 5.18 Optomap plus photo showed the lens dropped into lower part of vitreous cavity

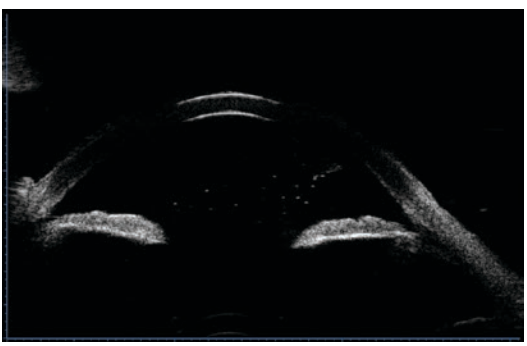

Fig. 5.19 UBM demonstrated deep anterior chamber, vitreous prolapse, and few pigment in anterior chamber without any lens reflection

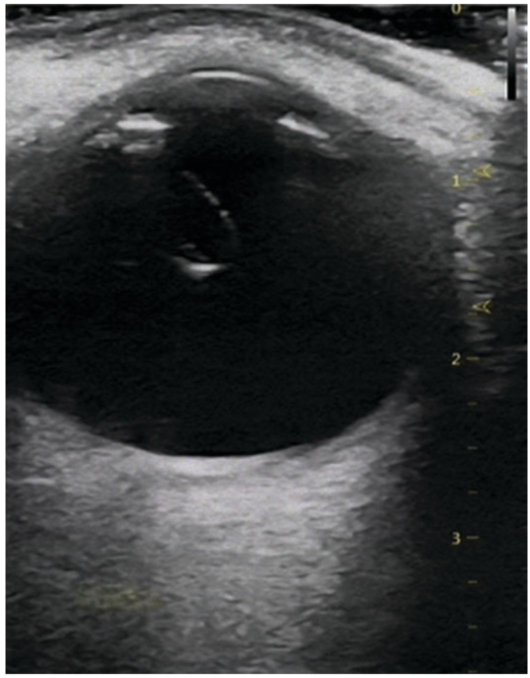

Fig. 5.20 B-scan ultrasonography of the right eye showed the whole lens dropped into vitreous cavity vertically with a small portion of the zonular linked to the ciliary body

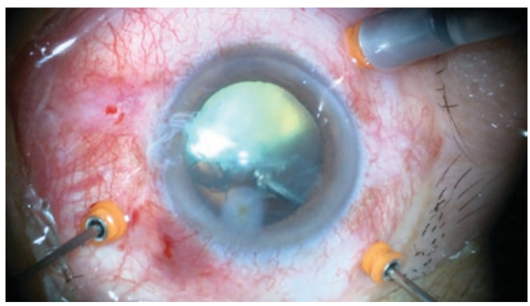

Fig. 5.21 The screenshots of the right eye during pars plana lensectomy and vitrectomy. The whole lens dropped into vitreous cavity and was easily removed by vitrectomy cutter

displayed in the pupil center after operation (Fig. 5.22). His vision improved to 0.8 2 months later after intraocular lens scleral fixation was performed. And the best corrected vision improved to 1.0 at the last follow-up visit.

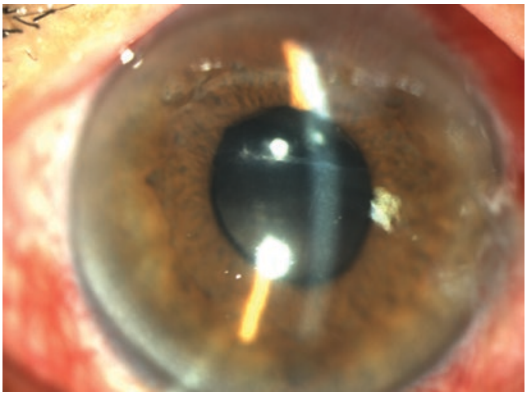

Fig. 5.22 Slit-lamp photograph on the first day after operation showed clear cornea, deep anterior chamber, and the gas-fluid interface in the pupil center

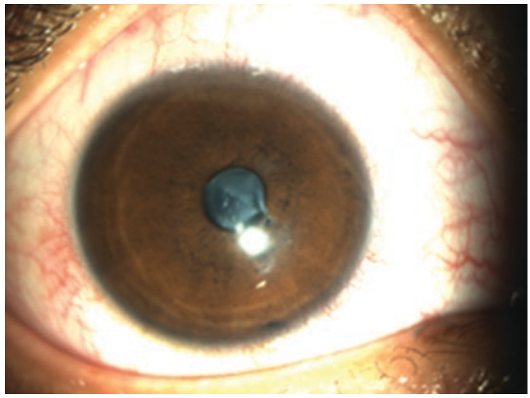

Fig. 5.23 The slit-lamp examination showed a rupture of the anterior lens capsule, small iris laceration, and opacity of the lens cortex with a partial outflow into anterior chamber

5.2.4.2 Tips and Pearls

With greater than 180° of zonular compromise, it's hard to keep posterior capsule intact. Anterior vitrectomy is usually performed to remove the vitreous prolapse. For removal of totally posterior dislocated crystalline lens, complete par plana lensectomy and vitrectomy are the methods of choice [6–10]. In order to lift the lens off the retina, the surgeon may use a cutter, a needle, or a perfluorocarbon liquid [11, 12]. Phacofragmentation can be considered in hard nuclear cataract cases. Without capsular bag, a scleral-fixated posterior chamber IOL or iris-fixated posterior chamber IOL and either an iris or angle fixated anterior chamber IOL may be used [13]. In our previous study, surgery that combined coreoplasty and artisan intraocular lens implantation was a safe and effective treatment for correcting aphakia and mydriasis in posttraumatic vitrectomized eyes [14].

5.3 Perforation or Penetrating Injury

5.3.1 Introduction

A sharp foreign body deep into lens may result in opacification of the cortex or nuclear at the site of the rupture, which is called perforation or penetration injury. A small perforating capsular injury may heal automatically particularly in child, resulting in a focal cortical cataract, and without any surgery involvement but in most cases develop to complete lens opacification, which need surgery removal.

5.3.2 Case: The Perforation Eye Injury Caused by a Steel Wire

5.3.2.1 Case Description

A 22-year-old male got sharp injury to his right eye. His best corrected vision decreased to 0.12 in 5 h. A steel wire penetrated into the cornea and lens, and then caused a rupture of the anterior lens capsule and the rapidly progressive cataract (Fig. 5.23). Thin slit beam demonstrates double cornea penetration sites and anterior lens capsule laceration (Fig. 5.24). An irrigation/aspiration apparatus was applied to remove the lens cortex and nuclear. The posterior lens capsule was protected and integrated well (Fig. 5.25). The IOL was implanted in the bag 7 days later after traumatic lens cortex culture was negative (Fig. 5.26). The cornea penetration site healed without suturing, and patient's vision increased 1.0 on the first day after operation (Fig. 5.27).

5.3.2.2 Tips and Pearls

Lens opacification can't be easily seen in small peripheral penetration. Thus careful examination

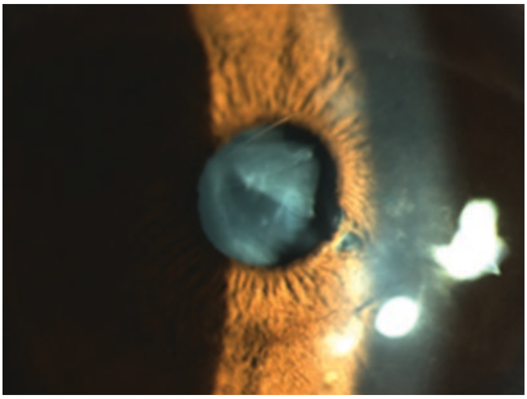

Fig. 5.24 Thin slit beam demonstrates double cornea penetration sites and anterior lens capsular laceration

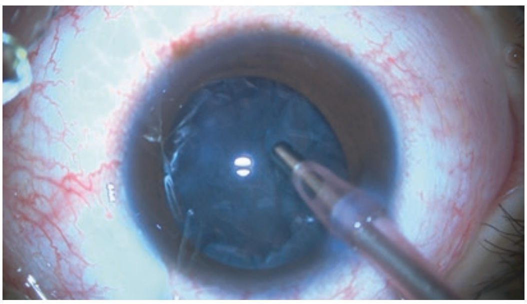

Fig. 5.25 The screenshot of the right eye during the irrigation/aspiration surgery. The posterior lens capsule was protected and integrated well

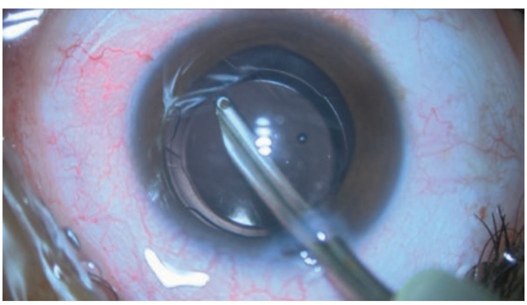

Fig. 5.26 The screenshot of the right eye during IOL implantation. The IOL was easily implanted in the bag 7 days later after traumatic lens cortex culture was negative

should be done with dilated pupil. X-ray examination or the orbital computerized tomography was used to confirm whether foreign body was present intraocularly. A small perforating capsule wound may heal automatically and focal cortical cataract formation which can be observed after initial treatment with topical steroids. If any complication develops, the cataract extraction should be done.

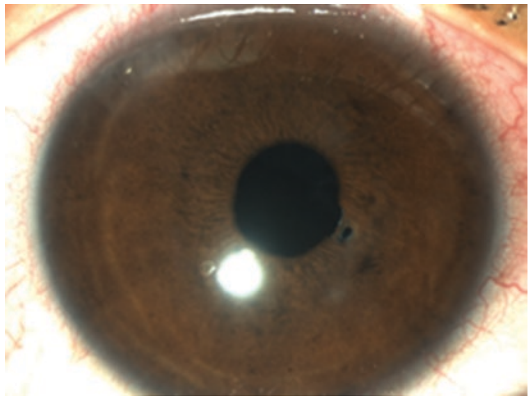

Fig. 5.27 The slit-lamp examination of the right eye on first day after operation showing the cornea penetration site healed without suturing, round pupil, and small iris laceration

5.4 Intralenticular Foreign Bodies

5.4.1 Introduction

A small sharp foreign body may perforate the cornea, the iris, the anterior lens capsule, and last stay within the lens, which is called intralenticular foreign body. Intralenticular foreign bodies are rarely seen, which constitute only 5% of all intraocular foreign bodies [15]. If small intralenticular foreign body is beyond the visual axis, patient gets good vision in early stage. But if the perforation site is in the center of the cornea or the intralenticular foreign body is in the center of the visual axis, vision decreases sharply. The foreign body may be retained within the lens without significance when the foreign body is not composed of a ferric or cupric material and the anterior lens capsular perforation site seals automatically. Iron or copper intralenticular foreign bodies can result in siderosis bulbi or chalcosis. Surgeons should remove them as early as possible.

5.4.2 Case: Intralenticular Foreign Metabolic Body Induced by a Nail

5.4.2.1 Case Description

A 50-year-old man presented to our eye clinic with blurring of vision for 3 months. He got a history of injury to his right eye half a year ago while hammering a nail at the construction workshop without any protective glasses at that time. On examination, his vision in the right eye dropped to 0.3. Slit-lamp photograph showed the intralenticular metallic foreign body in the posterior cortex of the lens when the pupil was dilated (Fig. 5.28). Computerized tomography showed high reflection in anterior segment of the right eyeball (Fig. 5.29). UBM showed the intact anterior lens capsule and local opacity (Fig. 5.30). Localized lens opacity displayed obviously under microscope during operation (Fig. 5.31). The metallic foreign body in the lens was removed with magnet before phacoemulsification (Fig. 5.32). The intraocular lens was implanted in the bag (Fig. 5.33). Patient's vision increased to 1.0 on the first day after operation.

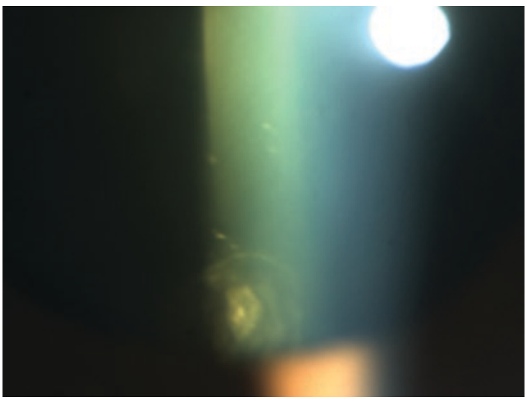

Fig. 5.28 Slit-lamp photograph showed the intralenticular metallic foreign body in the posterior cortex of the lens and no siderosis bulbi reflection after the pupil was dilated

Fig. 5.29 Orbital CT scans of the patient before surgery showed high reflection in the anterior segment of the right eyeball, which indicated the intraocular foreign body

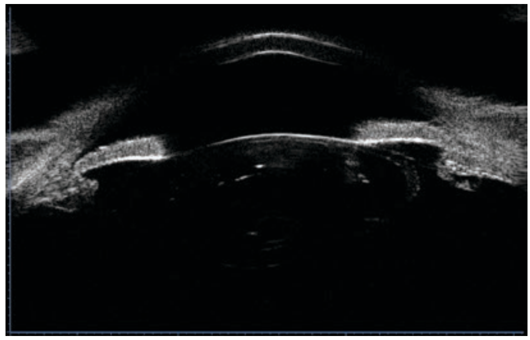

Fig. 5.30 UBM showed the intact anterior lens capsule and local opacity

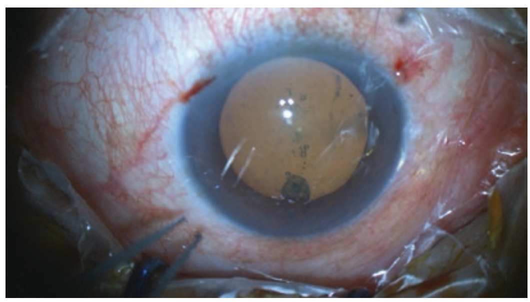

Fig. 5.31 The screenshot of the right eye before surgery showed localized lens opacity and intralenticular foreign body

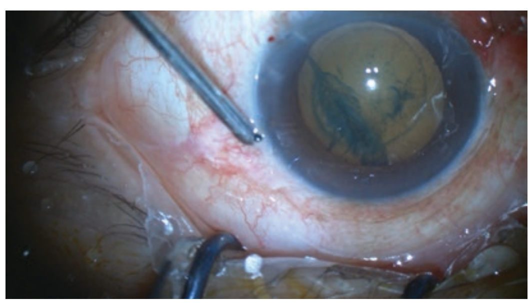

Fig. 5.32 The screenshot of the right eye during surgery. The intralenticular metallic foreign body was removed with magnet after capsulorhexis

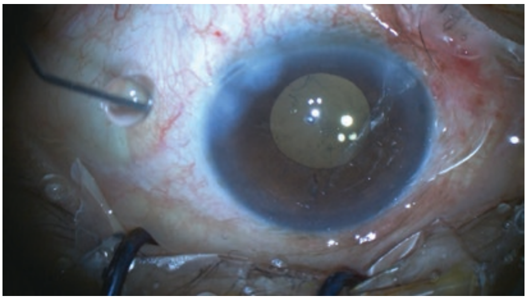

Fig. 5.33 The screenshot of the right eye at the end of the surgery showed intact posterior lens capsule and IOL implanted in the bag

5.4.2.2 Tips and Pearls

In many cases, cornea penetrating site self-sealed. Seidel's test was negative. Intraocular pressure was normal. Mild flare in anterior chamber was seen in early stage. The vision kept well at the early stage while rapid lens epithelial proliferation restoring its continuity. So it was important to dilate the pupil whether intralenticular foreign body was involved. CT was recommended before surgery to locate the foreign body. The posterior lens capsular should be protected well in order to avoid foreign body dropping into vitreous cavity. If flare in anterior chamber became worse before opertation, IOL implantation wasn't recommended in the early stage.

Although patients with a small embedded foreign body in the lens may have stable good vision for 40 years [16], or 60 years [17], but retained intralenticular iron may develop siderosis bulbi. Metallic foreign bodies in the lens should be removed as quickly as possible.

5.5 Siderosis Bulbi

5.5.1 Introduction

Iron or iron-containing intraocular foreign bodies deposit iron molecules into the cornea, anterior chamber, lens epithelium, iris, trabecular meshwork, vitreous, and retina, which are called siderosis bulbi. Affected lens show a yellowish tinge and then followed by a rusty brown discoloration. Besides it may cause iris discoloration, mydriasis, reduction in electroretinography amplitude, and glaucoma. Prompt surgical removal should be performed as soon as possible to prevent these complications [18, 19].

5.5.2 Case Siderosis Bulbi Caused by a Piece of Steel 3 Months Ago

5.5.2.1 Case Description

A 42-year-old woman presented with progressive decrease of vision in her left eye for 2 months. She got a history of trauma 3 months ago while hammering a stone using a steel without any protection. Except slightly foreign body sensation, she got good vision in primary trauma. She didn't care at the early stage. Best corrected vision acuity was 1.0 in her right eye and 0.05 in her left eye when she came to our outpatient room. The ocular examination of the right eye was normal. Slit-lamp examination of the left eye revealed tiny perforation site in temporal central cornea, a rusty brown discoloration in subcapsular cataract. The IOP was 16 mmHg. Fundus examination revealed an unknown retained intraocular foreign body in the lower part of the periphery retina.

Combined pars plana lensectomy and vitrectomy was performed under retrobulbar anesthesia (Fig. 5.34). The encapsulated intraocular foreign body (1.5 mm diameter) was dissected and sucked by vitrectomy cutter, lifted upon the anterior lens capsule, and then removed by magnet through

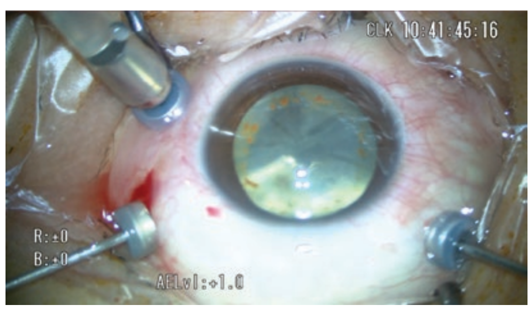

Fig. 5.34 The screenshot of the left eye during vitrectomy showed a rusty brown discoloration in subcapsular cataract

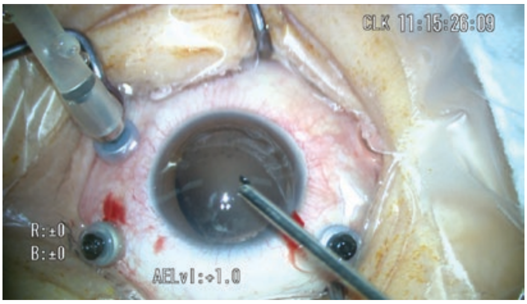

Fig. 5.35 The screenshot of the left eye during vitrectomy. The intraocular foreign body (a piece of steel, 1.5 mm diameter) was dissected and sucked by vitrectomy cutter, lifted upon the anterior lens capsule, and then removed by magnet through limbal cornea incision

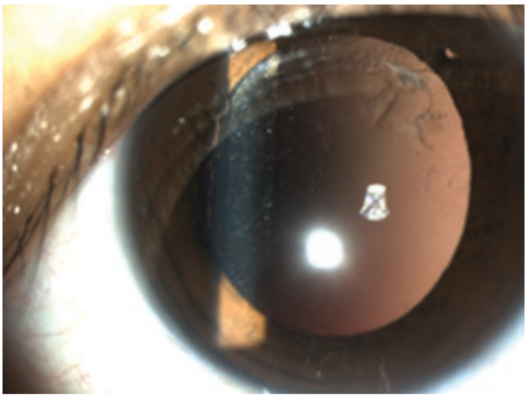

Fig. 5.36 The slit-lamp image of the left eye on the first day after pars plana lensectomy and vitrectomy showed no yellowish tinge on the anterior lens capsule but the small entrance site of the foreign body. The anterior lens capsule was almost intact

limbal cornea incision (Fig. 5.35). She got best corrected visual acuity of 0.6 on first day after surgery, and the anterior lens capsule was almost intact except the small entrance site (Fig. 5.36). IOL was easily implanted in the sulcus 2 months later. At the final examination, the visual acuity was 1.0, the IOP was 16 mmHg without any pain, redness, or irritation, and the IOL was stable (Fig. 5.37).

5.5.2.2 Tips and Pearls

Most cases with siderosis bulbi had a definite history of trauma. X-ray examination or the orbital computerized tomography was usually used to confirm the presence and location of intraocular

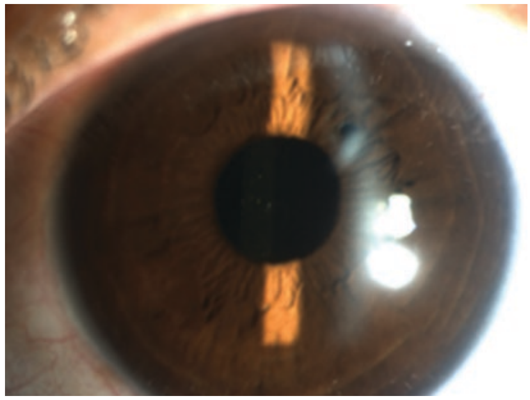

Fig. 5.37 The slit-lamp examination of the left eye 2 months after the IOL implantation showed the original penetration cornea scar, clear anterior chamber, and centered IOL

foreign body. Wu et al. [20] and DeAngelis et al. [21] also described radiologically undetectable foreign bodies, but in their cases, metallic intraocular foreign bodies were removed during surgeries. The electroretinography (ERG) was also tested to detect possible toxic retinal damage preoperatively.

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Vitreous Hemorrhage

6

Xuemin Jin, Dong Qin, Yanting Wang, Shuangshuang Li, Jinfeng Han, and Mengdi Li

Abstract

The vitreous body is the clear gel-like substance that fills the space between the lens and the retina of humans. Its primary function is to keep the center of the eye clear. The presence of extravasated blood within the vitreous body is defined as vitreous hemorrhage. This condition may result from diseased retinal vessels or abnormal new vessels, rupture of normal retinal vessels, and/or spread of hemorrhage into vitreous from any other intraocular sources. Trauma is the leading cause of vitreous hemorrhage in young people and can be caused both by closed and open globe injury. It is always accompanied by many complications. If not handled properly, it may cause permanent blindness. Management of traumatic vitreous hemorrhage is complex and varies for each individual and each trauma. Eyes with small or moderate vitreous hemorrhage without obvious complications could be observed closely. In cases of vitreous hemorrhage associated with various anterior and posterior segment pathologies, early vitrectomy is recommended to provide early visual rehabilitation and management of any potentially treatable pathology. Timely and aggressive management of these injuries will offer the patient the best chances to salvage the eye and regain vision. But, in some severely injured eyes, all the efforts may be in vain, and ocular injury prevention is still the most important thing.

Keywords

Vitreous body · Vitreous hemorrhage · Closed globe injury · Open globe injury · Vitrectomy

6.1 Introduction

The vitreous body, also called secondary vitreous, vitreous humor, or simply "the vitreous," is the clear gel-like substance that fills the space between the lens and the retina (80% of the volume of the eyeball) of humans. It is derived from the retina and mesoderm of the hyaloid system and begins to develop at the 13 mm stage [1].

The vitreous body is spherical somewhat but slightly flattened meridionally. It is composed 99% of water, and the remaining 1% substances are salts, sugars, vitrosin (a type of collagen), a network of collagen type II fibrils with glycosaminoglycan, hyaluronan, opticin, and a wide array of proteins. These components account for the gelatinous but clear nature of the vitreous and the fluid-like characteristic near the center and gel-like near the edges [1, 2].

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The vitreous surface is surrounded by a layer of collagen called vitreous membrane (or hyaloid membrane or vitreous cortex) separating it from the contiguous structures, but the firmness of attachment of vitreous cortex to these tissues is different. The most firmly attached place is at the vitreous base; here the density of the collagen of the vitreous is greatest. Other relatively firm attachment areas are at margin of the optic nerve head, fovea-parafoveal area, along major retinal blood vessels, and the lens [1].

The primary function of the vitreous is to keep the center of the eye clear. It is also important to keep the shape and pressure of the eye. In youth, the vitreous body is a shock absorber during eye, head, and body movement, and the anterior (in the front just behind the lens) vitreous seems to support the lens and assist in its function focusing vision at near distance when we read. Recent years' studies also implicate the vitreous gel has a protective effect in several ocular disease processes involving oxidative damage, including nuclear sclerotic cataracts and open-angle glaucoma. Additionally, we also use the vitreous as a reservoir for drugs clinically, which we inject drugs into the eye to treat various diseases of the macula and retina [1].

The vitreous humor can become less gel-like and more liquefied with aging and result in posterior vitreous detachment (PVD), pathological myopia, and ocular trauma; ocular surgery could decelerate the process. The liquefaction can cause detachment of fibers from the retina and float freely through the vitreous humor. These floaters sometimes become noticeable in people's field of vision, appearing as dust, strings, dots, or cobwebs. PVD does not directly threaten vision, but it might play a decisive role in the development of major pathologic vitreoretinal conditions, such as retinal tears with or without vitreous hemorrhage, epiretinal membrane, macular hole, and so on.

Vitreous hemorrhage is defined as the presence of extravasated blood within the vitreous body. This condition may result from diseased retinal vessels or abnormal new vessels, rupture of normal retinal vessels, and/or spread of hemorrhage into vitreous from any other intraocular sources. Proliferative diabetic retinopathy, PVD with or without retinal tear, and ocular trauma are the three most common causes. Clinically, it is not easy to distinguish blood actually within the vitreous from subinternal limiting membrane hemorrhage and from preretinal hemorrhages, so these conditions are also considered types of vitreous hemorrhage [3–6].

Trauma is the leading cause of vitreous hemorrhage in young people. It accounts for 12–18.8% of cases in adults and has a higher incidence in males than females. Ocular contusion, penetrating or perforating ocular injury, intraocular foreign body, and globe rupture all can cause disruption of normal ocular vessels and vitreous hemorrhage. Small vitreous hemorrhage often is perceived as new multiple floaters, moderate vitreous hemorrhage is perceived as dark streaks, and dense vitreous hemorrhage tends to significantly decrease vision even to light perception [5, 6].

For patients with traumatic vitreous hemorrhage, complete eye examination should be performed, including slit lamp examination, intraocular pressure, and dilated fundus examination. In some cases, B-scan ultrasonography, UBM, CT scan, and/or MRI is needed to exclude globe perforation, intraocular foreign body, retinal tear, or retinal detachment.

The management of traumatic vitreous hemorrhage depends on the underlying causes. Eyes with small or moderate vitreous hemorrhage without obvious complications could be observed closely. In cases of vitreous hemorrhage associated with various anterior and posterior segment pathologies, early vitrectomy is recommended to provide early visual rehabilitation and management of any potentially treatable pathology [5, 6].

6.2 Vitreous Hemorrhage from Closed Globe Injury

6.2.1 Case #1: Vitreous Hemorrhage Because of Choroidal Rupture

A 28-year-old man was referred to our hospital with the diagnosis of traumatic vitreous hemorrhage in the right eye for 1 week. One week ago, he sustained a blow with a clenched fist and vision decreased in the right eye. He attended a local clinic 2 h later and was diagnosed with traumatic vitreous hemorrhage. Some anti-inflammation eye drops were prescribed, but there was no change of vision after 1 week of observation. Our examination revealed the best-corrected visual acuity in the right eye was 20/200 and 20/20 in the left eye with −3.0DS lens. The intraocular pressure (IOP) of his right and left eye was 35 and 19 mmHg, respectively. Ultrasound biomicroscopy (UBM) did not find abnormality in the anterior segment of the right eye. Pieces and lumpy blood floating in the vitreous body and B-scan ultrasonography showed vitreous opacity (Fig. 6.1). Inferior and inferotemporal to the optic nerve, there were crescent and irregular subretinal white/yellow streaks (choroidal rupture) accompanied with dots and patchy fresh blood (Fig. 6.2).

Brinzolamide and brimonidine eye drops were used, one drop two times a day separately, and the IOP was controlled to normal 2 days later; then the eye drops were reduced gradually. Two weeks later, most of the vitreous hemorrhage absorbed and the BCVA improved to 20/60; IOP was 16 mmHg without antiglaucoma eye drops. The choroidal rupture was more obvious with ophthalmoscopic examination (Fig. 6.3), optical coherence tomography (OCT) (Fig. 6.4), and fluorescein/indocyanine green angiography (FA/ICGA) (Fig. 6.5). Two months after injury, the BCVA in the right eye kept stable, but the choroid along the rupture became atrophy more obviously (Fig. 6.6).

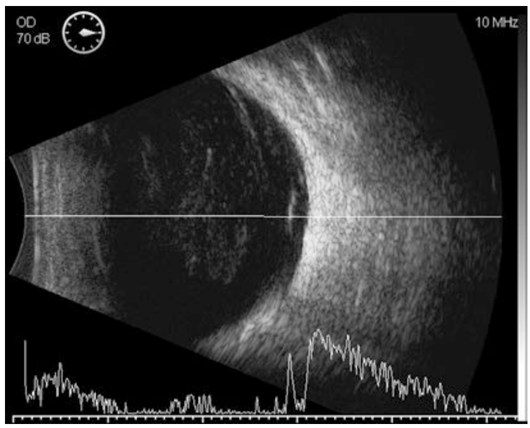

Fig. 6.1 Initial B-scan ultrasonography indicated vitreous opacity

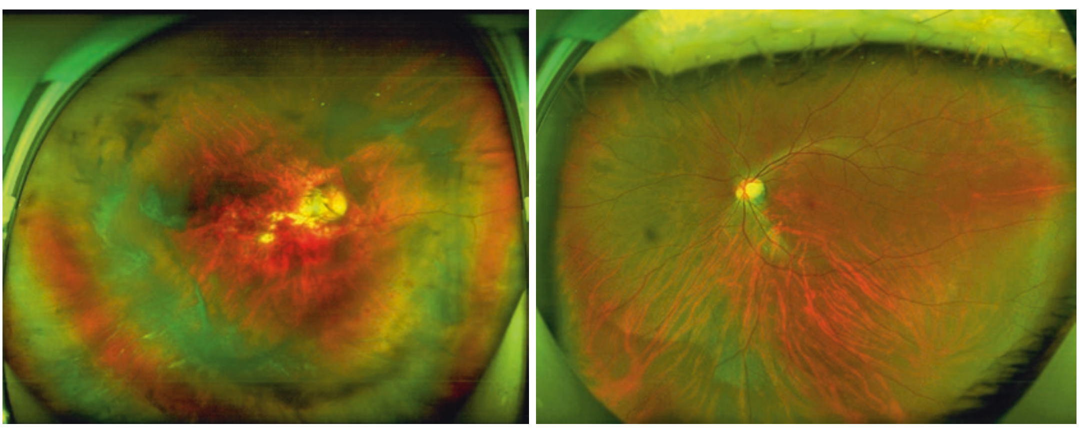

Fig. 6.2 Fundus photography early after trauma showed vitreous hemorrhage and choroidal rupture accompanied with subretinal fresh blood in the right eye (*right*), and the left eye was normal (*left*)

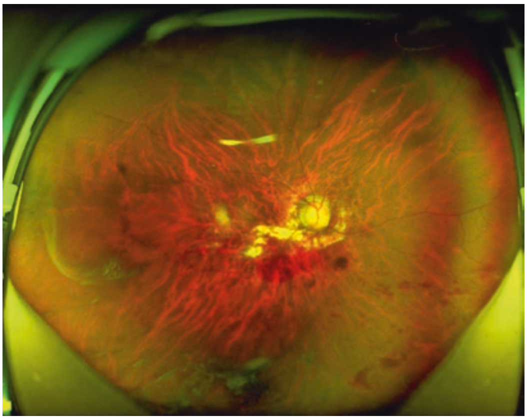

Fig. 6.3 Fundus photography showed vitreous hemorrhage absorbed greatly 3 weeks after injury

6.2.2 Case #2: Vitreous Hemorrhage Because of Contusive Retinal Injury

A 10-year-old boy was brought to our clinic complaining of fireworks injury and reduced visual acuity in the left eye for 7 days. After injury, he received treatment in the local hospital for the periorbital superficial skin burns and lower eyelid laceration repair (Fig. 6.7) immediately. On our examination, the best-corrected visual acuity (BCVA) was 1.0 and HM/10 cm in the right and left eye, respectively. Intraocular pressures were 20 mmHg in the right eye and 4 mmHg in

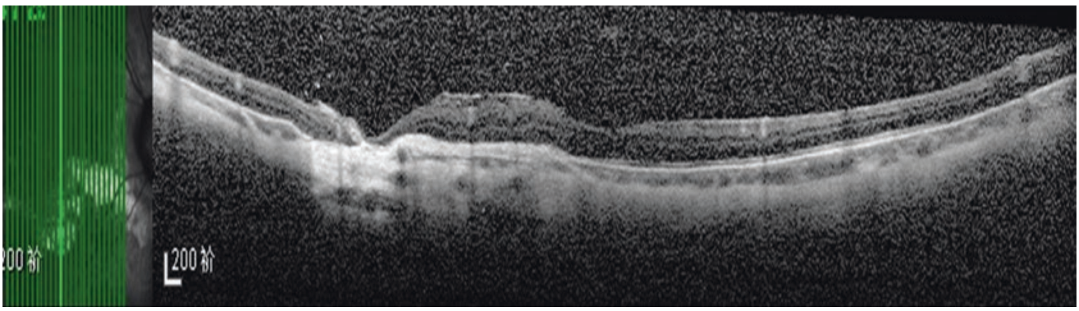

Fig. 6.4 OCT revealed thinner neuroretina, absence of RPE, and choroidal atrophy coincided the rupture 3 weeks after injury

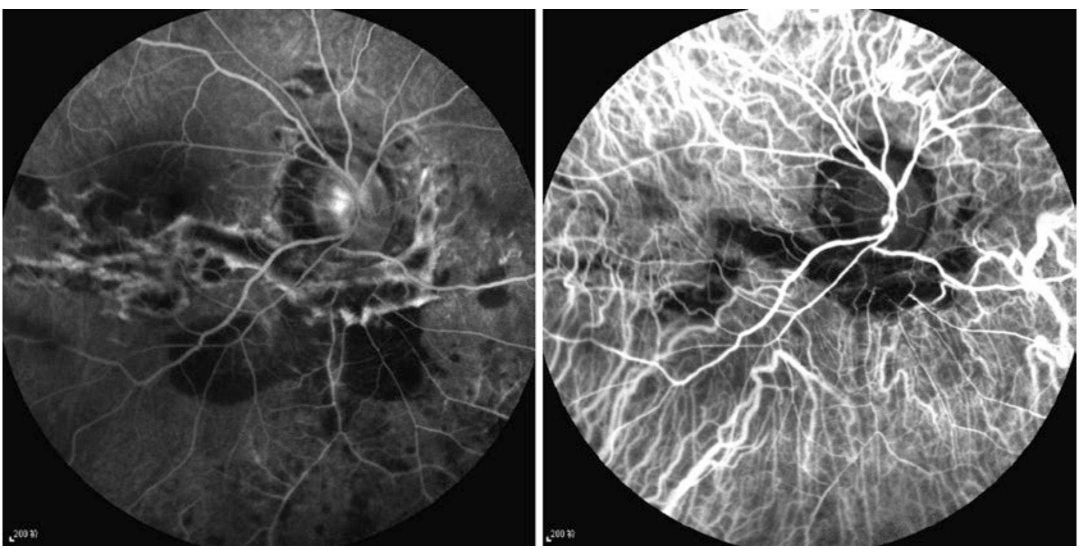

Fig. 6.5 FA + ICGA showing choroidal rupture streaks and subretinal hemorrhage

the left. Slit lamp examination revealed the right anterior chamber was blurred because of fresh blood (Fig. 6.8), the vitreous body was hemorrhagic cloudy, and the fundus was invisible. B-ultrasound showed vitreous opacity, retinal and choroidal detachment were suspected, and the wall of eyeball was thickened (Fig. 6.9). Topical steroids and cycloplegics eye drops were used for 1 week, the hyphema decreased obviously, and iridodialysis was seen at the temporal side (Fig. 6.10). But there was no obvious change on B-ultrasound and UBM showed iridodialysis and cyclodialysis existed.

On the 14th day after injury, pars plana vitrectomy was done for the left eye. After cleaning most of the vitreous hemorrhage, the residue vitreous cortex was stained with triamcinolone acetonide and peeled from the posterior swollen retina. But, at the temporal side, the peripheral retina was like necrosis and merged with pre- and subretinal hemorrhage (Fig. 6.11). The hemorrhage on the retina surface was difficult to cut or peel off and the retina easy to be teared, so it was kept in place and silicone oil was filled. Three days after the surgery, most of the retina kept attachment except hemorrhage at the temporal

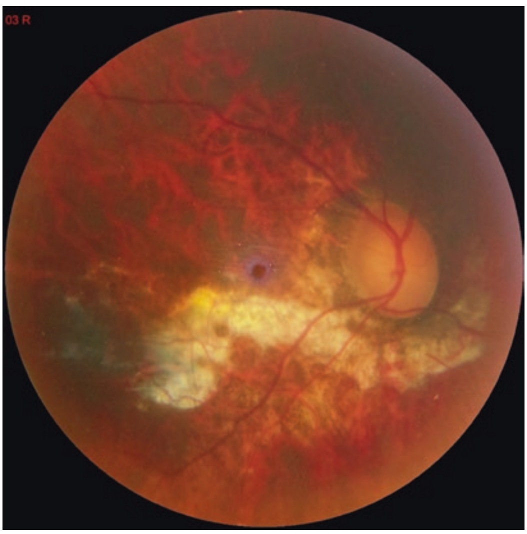

Fig. 6.6 Three months after injury, fundus photography showed obvious choroidal atrophy along the rupture streaks

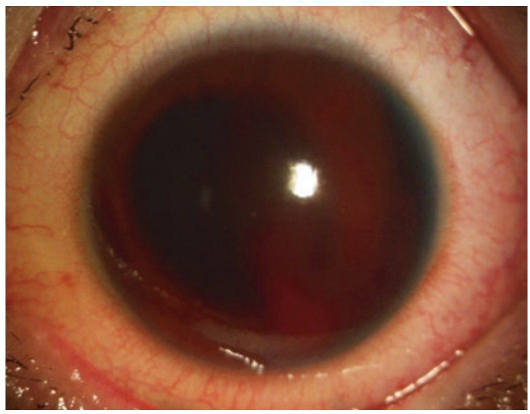

Fig. 6.8 Fresh blood in the anterior chamber

Fig. 6.7 Periorbital superficial skin burns and lower eyelid laceration of the left eye

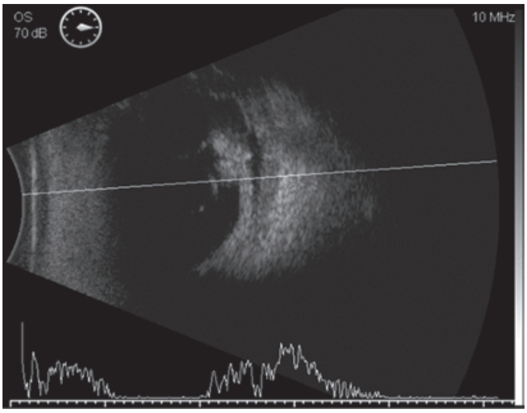

Fig. 6.9 Vitreous opacity, suspected retinal and choroidal detachment, thickening of the ocular wall on B-ultrasound

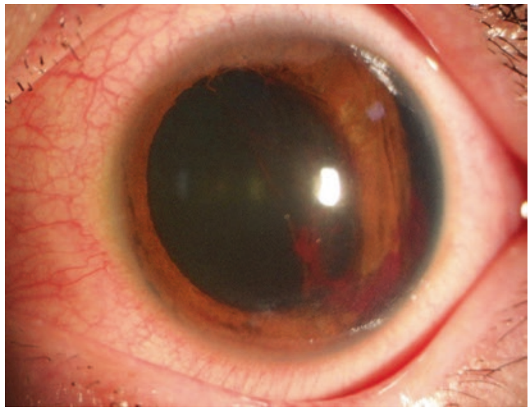

Fig. 6.10 Clotted anterior hemorrhage and temporal iridodialysis

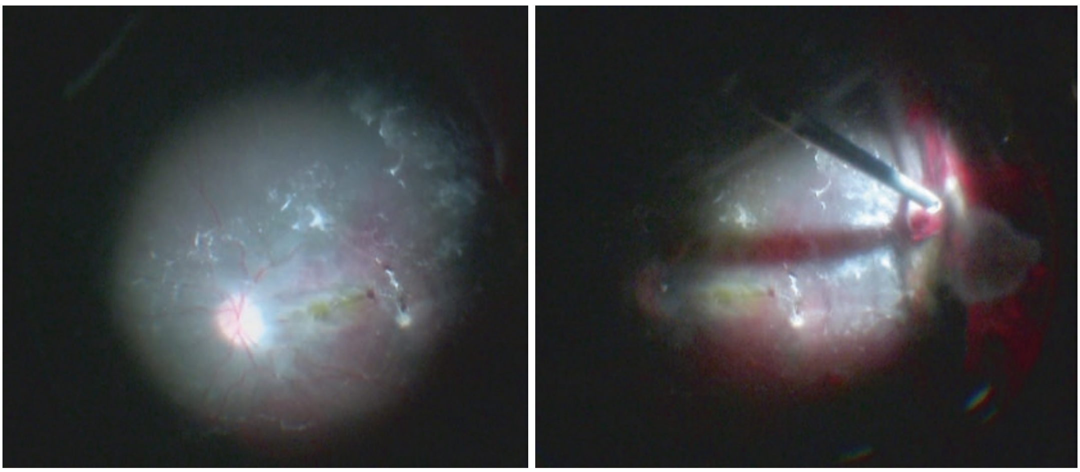

Fig. 6.11 The posterior retina is swollen (*right*) and the peripheral retina at the temporal side is merged with pre- and subretinal hemorrhage (*left*)

side (Fig. 6.12). IOP improved to 12 mm Hg and visual acuity was HM/5 cm in the left eye.

6.2.3 Tips and Pearls

Closed globe trauma [7] or non-penetrating injury is the most common eye injury and always caused by blunt objects or in explosive accidents. It may occur after blunt injury during motor vehicle accidents, sports activity, assault, or other trauma. Besides the eyeball itself, the surrounding area, including adjacent tissue and bone structure, may be involved (case #2).

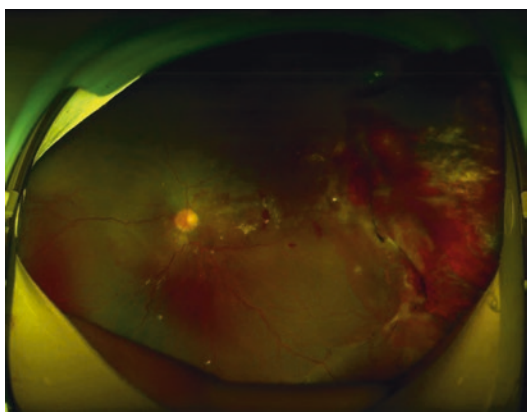

Fig. 6.12 Fundus photography showed most of the retina were flat except preretinal hemorrhage at the temporal side

In severe blunt injury, the globe is compressed anteroposteriorly and stretched equatorially, which causes damage to many of the ocular tissues, such as corneal edema, hyphema, iridodialysis, cyclodialysis, lens subluxation or dislocation, vitreous hemorrhage, commotio retinae or retinal breaks, retinal detachment (case #2), choroidal rupture (case #1), and even optic nerve damage [8, 9]. So when a patient who has suffered ocular trauma is first seen, the initial objective must be to determine the nature and extent of the injury.

Vitreous hemorrhage is common in blunt ocular injury. Ocular contusion can cause disruption of normal ocular vessels and vitreous hemorrhage. Complete eye examination, including slit lamp examination, intraocular pressure, and dilated fundus examination, B-scan ultrasonography, UBM, CT scan, and/or MRI is needed to find and evaluate the related injuries. In eyes with small or moderate vitreous hemorrhage without obvious complications, such as choroidal rupture, the blood always absorbs in a few days. But, in eyes with severe vitreous hemorrhage, prompt vitrectomy is always needed to clear blood and deal with other treatable complications.

6.3 Vitreous Hemorrhage from Open Globe Injury

6.3.1 Case #1: Vitreous Hemorrhage Because of Anterior Penetrating Ocular Injury

A 37-year-old man was referred to our hospital with penetrating injury of the right eye for 3 days. Three days ago, the patient's right eye was wounded by a steel wire while working by accident. He pulled out the steel wire by himself but found out he could not see anything with the right eye, and then he presented to the local hospital in emergency room. Because of the lack of equipment and skill, he was referred to our hospital. On examination, his visual acuity was light perception in the right eye and 20/20 in his left eye. The intraocular pressure (IOP) of his right and left eye were 12 and 16 mmHg, respectively. Slit lamp examination showed conjunctival congestion and a suspected self-closed conjunctival/scleral wound 2–3 mm posterior to the limbus at the superior nasal quadrant. There was fresh blood in the anterior chamber and a small pool at the bottom. The lens became cloudy mildly and there was dense bloody opacity in vitreous. Ocular CT scan was done and intraocular foreign body was excluded. B-scan ultrasonography indicated vitreous opacity, posterior pole ocular wall-penetrating wound, and shallow retinal detachment (Figs. 6.13 and 6.14).

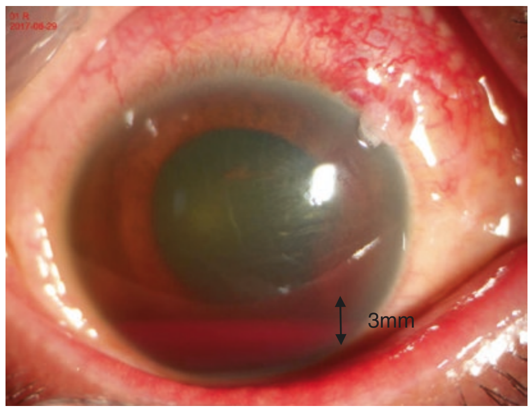

Fig. 6.13 Conjunctival congestion, a suspected self-closed conjunctival/scleral wound 2–3 mm posterior to the limbus at the superior nasal quadrant and hyphema

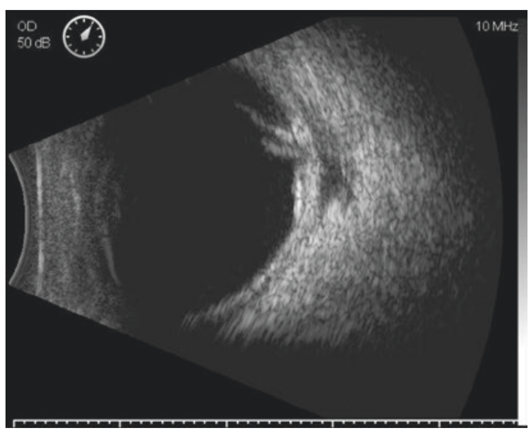

Fig. 6.14 B-scan ultrasonography indicated vitreous opacity, posterior pole ocular wall-penetrating wound, and shallow retinal detachment

After completing related examination, anterior chamber irrigation and pars plana vitrectomy were performed. During surgery, a 5 mm full layer scleral laceration about 3 mm posterior to the limbus at the preoperative suspected self-closed wound was found and repaired. After cleaning the vitreous hemorrhage, retinal tear with peripheral retinal detachment and subretinal hemorrhage were also discovered at the superior nasal place. Retinal tear was closed with photocoagulation and silicone oil was injected (Fig. 6.15). Two months after surgery, the BCVA was improved to 20/100 (Fig. 6.16).

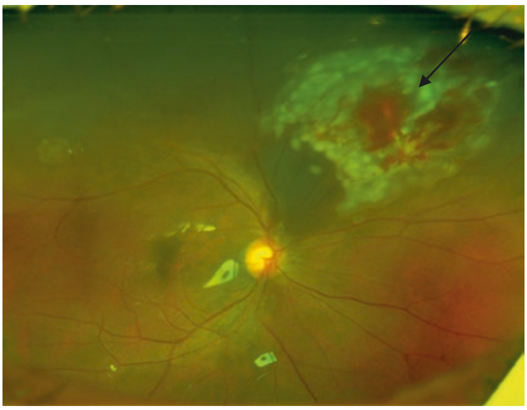

Fig. 6.15 Fundus photography 2 days after operation showed the retinal tear was closed by photocoagulation

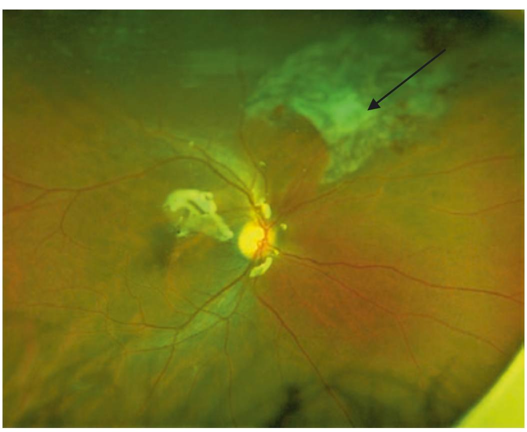

Fig. 6.16 Fundus photography 2 month after operation showed closed retinal tear

6.3.2 Case #2: Intraocular Foreign Body with Vitreous Hemorrhage

The patient, a 22-year-old man, was stabbed by a nail in the right eye while working, 2 h prior to admission to a local hospital. He was noted to have a scleral laceration, 3.5 mm posterior to the limbus. Suture of the scleral laceration was then performed at the local hospital and fundus photography showed vitreous hemorrhage (Fig. 6.17a). After 3 months, he came to our hospital with complaint of a wirelike floater in his right eye. His BCVA in both eyes was 20/20. The IOP was 17.2 mmHg in the right eye and 18.4 mmHg in the left eye. Ophthalmoscopic examination found an eyelash-like foreign body floating in the inferior nasal peripheral vitreous, and B-ultrasound examination showed local vitreous opacity (Fig. 6.17b, c). There were no signs of infection in his right eye, but the patient could not stand the wirelike floater. A pars plana vitrectomy (PPV) was then performed. During the PPV, an eyelash was clearly seen (Fig. 6.17d). We speculate that the eyelash might enter the vitreous cavity from the wound. After 1 month, the BCVA in the right eye was kept 20/20 and the IOP was 16.8 mmHg. No surgical-related complication took place.

6.3.3 Case #3: Vitreous Hemorrhage Because of Perforating Ocular Injury

A 71-year-old man was referred to our hospital with the possible diagnosis of perforating ocular injury. Five days ago, the patient received retrobulbar anesthesia in his left eye in a village clinic for cataract surgery. Before the injection of anesthetic, the patient felt pain and visual loss in the left eye and the surgery was stopped. Later, the patient was transferred to our hospital because related examinations suggested vitreous hemorrhage and retinal detachment. On examination, his BCVA in the left eye was hand motion and 20/60 in the right eye. The IOP was

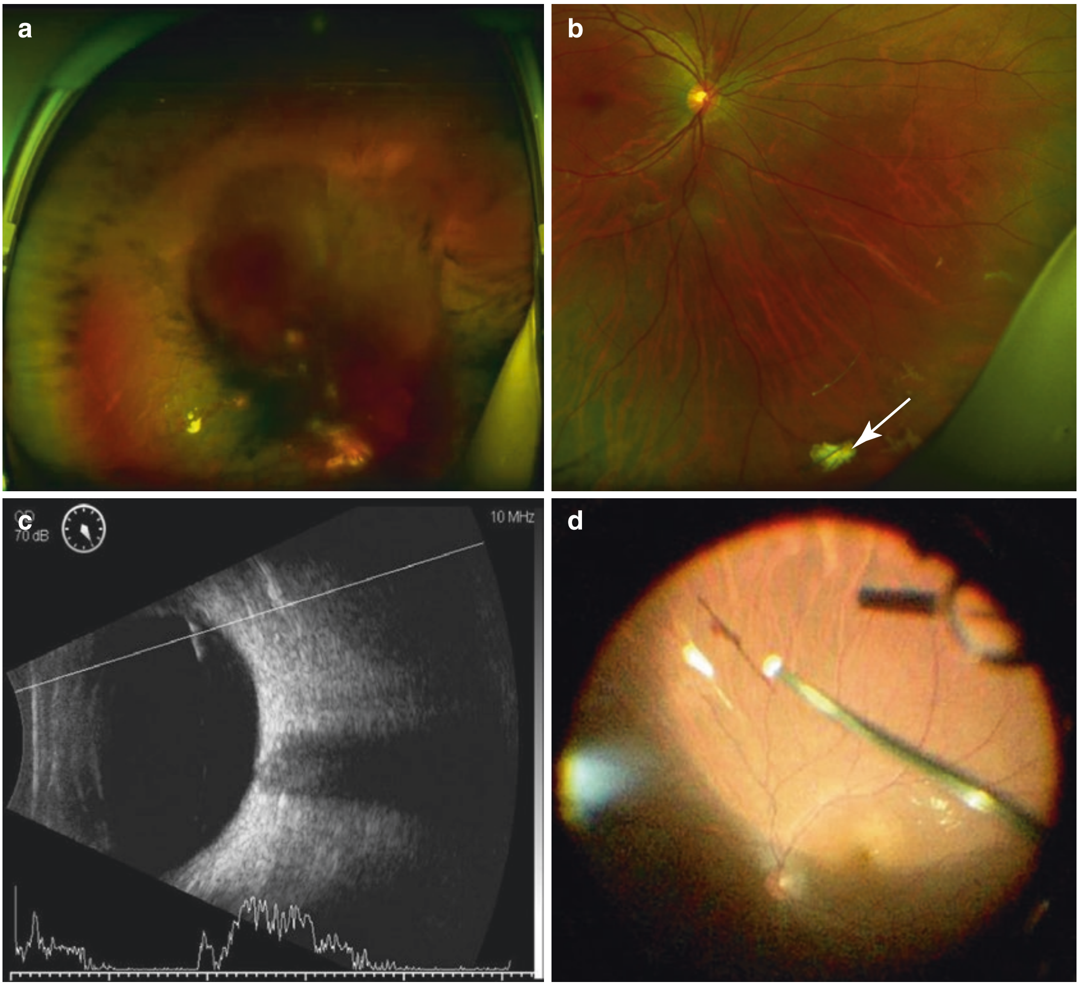

Fig. 6.17 Photographs of the right eye. The photograph shows vitreous hemorrhage (**a**) and an eyelash-like foreign body in the right eye (**b**). B-ultrasound examination shows local vitreous opacity without retinal detachment (**c**). During the surgery, the eyelash was clear observed (**d**). The arrow indicates eyelash-like foreign body

19.2 mmHg in the left eye and 17.4 mmHg in the right eye. The lens in the left eye was moderate opacity (Fig. 6.18a) and intraocular lens in the right eye. The vitreous was filled with dense fresh blood and B-ultrasound showed vitreous opacity and retinal detachment (Fig. 6.18b). Pars plana vitrectomy was then performed on the left eye. During surgery, the perforating tract was found at the inferior temporal quadrant and 2–3DD away optic disc with retinal tear and detachment around it (Fig. 6.19a). Laser photocoagulation around the retinal break was performed and 4.2 mL silicone oil was injected into the vitreous cavity. One month after surgery, the BCVA was 20/150, the IOP was 10 mmHg and retinal break was closed in the left eye (Fig. 6.19b).

6.3.4 Case #4: Vitreous Hemorrhage After Corneal Rupture

A 60-year-old man with 1 year of cataract surgery history got hurt in the right eye because of falling down from stairs. He presented to the

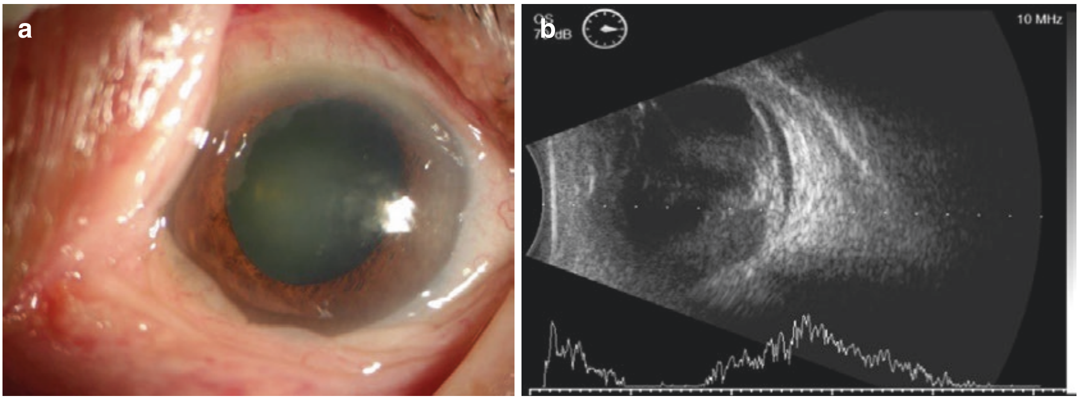

Fig. 6.18 Photographs of the left eye. The photograph shows a cataract in the left eye (**a**), and B-ultrasound examination shows vitreous hemorrhage and retinal detachment (**b**)

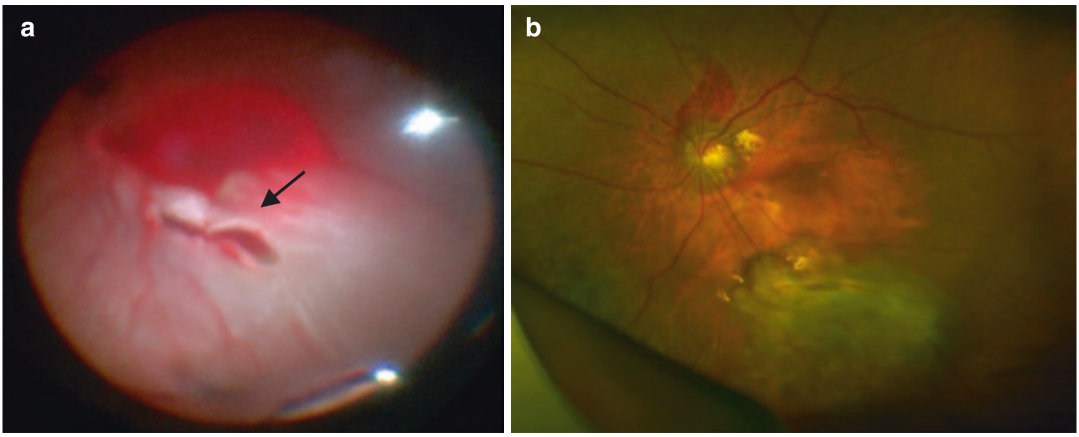

Fig. 6.19 Photographs of the fundus of the left eye. The perforating tract with retinal tear and detachment (**a**). One month after surgery, the photograph showed a flat retina (**b**). The arrow indicates retinal tear

local hospital and received dislocated intraocular lens extraction and corneal rupture repair. After 10 days of hospitalization, he was referred to our hospital for the treatment of intraocular hemorrhage. His best-corrected visual acuity (BCVA) in the right eye was HM/30 cm and in the left eye was 20/50. The intraocular pressure (IOP) was 6 mmHg in the right eye and 13 mmHg in the left eye. Examination of the right eye showed sutures in the cornea, absence of iris and lens, and hemorrhage filled the eye (Fig. 6.20). CT showed absence of the lens and no intraocular foreign body existed. B-ultrasound examination showed vitreous opacity and suspected retinal

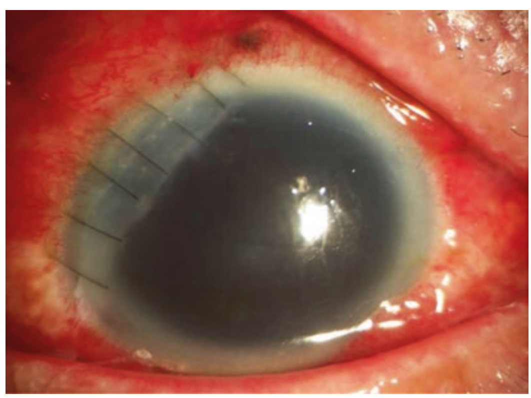

Fig. 6.20 Anterior ocular photography of the right eye. Corneal sutures exist and the iris is absent

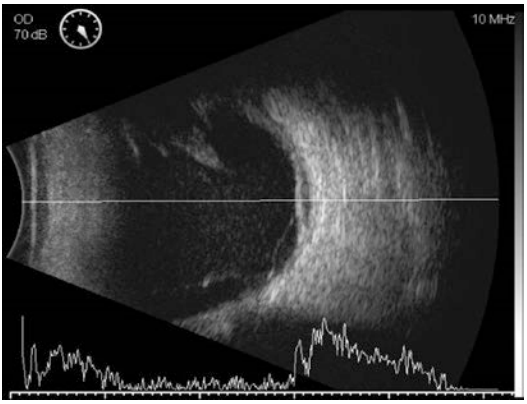

Fig. 6.21 B-ultrasound examination in the right eye. The vitreous is opacity and retinal detachment is suspected

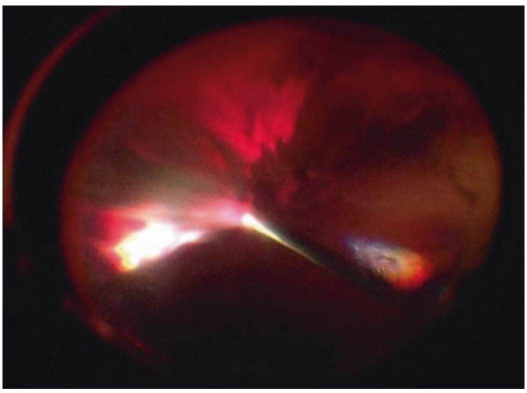

Fig. 6.22 Photograph of the right eye during surgery. Dense vitreous hemorrhage exists

detachment (Fig. 6.21). A pars plana vitrectomy (PPV) was conducted on the 11th day of injury. During the operation, severe vitreous hemorrhage (Fig. 6.22) was identified but no retinal detachment was found. Air-fluid exchange was done, and after air absorption, BCVA recovered to 20/60 in the right eye.

6.3.5 Case #5: Vitreous Hemorrhage Because of Corneal-Scleral Rupture

A 54-year-old man presented to our emergency clinic with the complaint of left eye injury by his myopic glass in a car accident for 10 h. The BCVA in his left eye was light perception and 20/20 in the right eye. The IOP was 5.6 mmHg in the left eye and 11.4 mmHg in the right eye. Slit lamp examination of the left eye showed an irregular corneal and scleral rupture near 12 o'clock, and the iris was incarcerated in the wound and was covered by fibrinous membrane. The anterior chamber depth was normal and there was blood in the inferior part. The pupil was irregular, the lens was mildly cloudy, and fresh blood filled the vitreous body (Fig. 6.23a). There was nothing remarkable in the right eye. Orbital CT scanning was done to exclude intraocular foreign body and the wound was sutured in emergency. Antibiotics and anti-inflammation eye drops were used usually. One week after surgery, there was no decreasing sign for vitreous hemorrhage (Fig. 6.23b) and B-ultrasound examination showed retinal and choroidal detachment (Fig. 6.23c). Then par plana lensectomy and pars plana vitrectomy (PPV) were performed. During surgery, the scleral and ciliary body injury was seen near the ora serrata but did not reach neuroretina; the peripheral retinal and choroidal detachment existed from 10:00–5:00 (Fig. 6.24a). After cleaning the opacified vitreous, 3.6 mL of silicone oil was injected into the vitreous cavity. One month after PPV, the BCVA was 20/200 and the IOP was 10 mmHg in the left eye. A color fundus photograph showed a flat retina (Fig. 6.24b).

6.3.6 Case #6: Vitreous Hemorrhage Resulted from Anterior Scleral Rupture

A 54-year-old man was referred to our hospital because of traumatic vitreous hemorrhage in the right eye. His right eye was wounded by a fist 12 days ago, and a scleral laceration near limbus was sutured in the local hospital in the emergency room. The best-corrected visual acuity (BCVA) in the right eye was light perception and 20/20 in the left eye. The intraocular pressure (IOP) was 16.2 mmHg in the right eye and 11.4 mmHg in the left eye. Ophthalmic examination of the right eye showed conjunctival

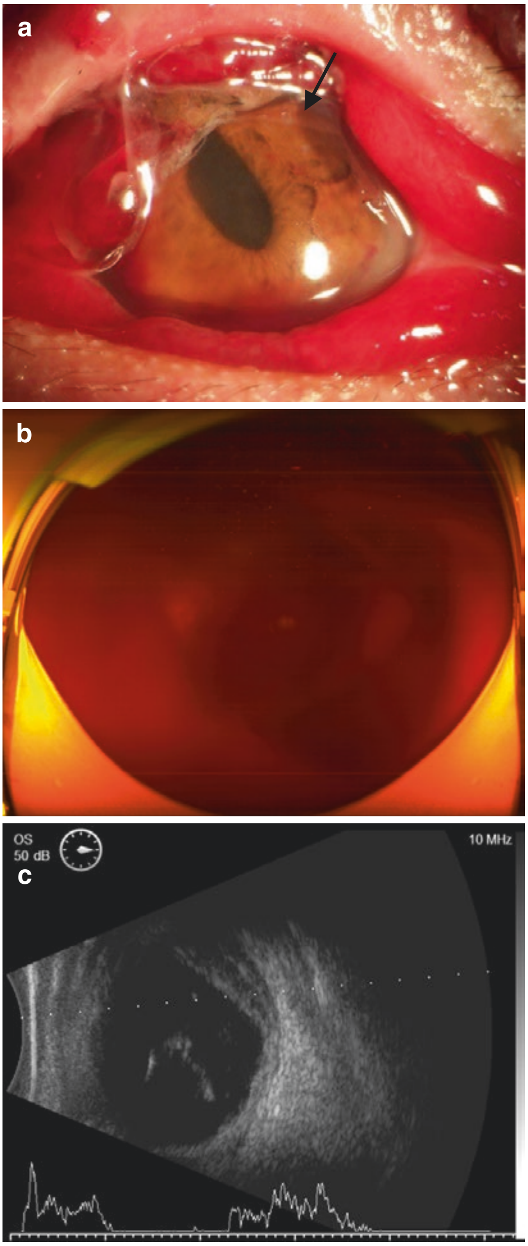

Fig. 6.23 Photographs of the left eye. (**a**) The photograph showed corneal and scleral rupture, the iris prolapsed from a corneal wound and covered with fibrinous membrane; (**b**) vitreous hemorrhage; (**c**) and B-ultrasound examination showed retinal and choroidal detachment. The arrow indicates iris prolapse from a corneal wound

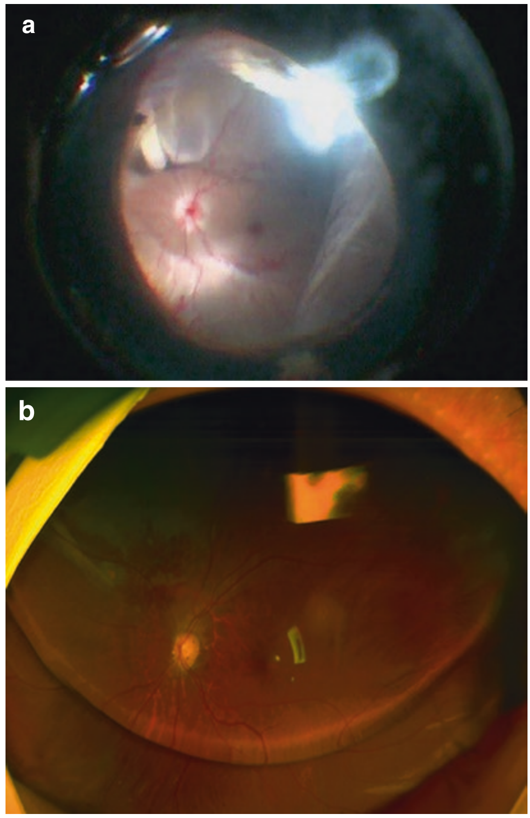

Fig. 6.24 Photographs of the fundus of the left eye. (**a**) During the operation, retinal and choroidal detachment was clearly seen. (**b**) One month later, the photograph showed the flat fundus

scar (Fig. 6.25a), corneal edema (Fig. 6.25b), absence of the lens (Fig. 6.25b), anterior chamber and vitreous hemorrhage (Fig. 6.25c), and possible retinal and choroidal detachment with B-ultrasound scanning (Fig. 6.25d). As a result, a pars plana vitrectomy (PPV) was conducted. After cleaning the vitreous hemorrhage (Fig. 6.26a), the retinal and blood choroidal detachment (Fig. 6.26b) were confirmed and no retinal tear was found. The subchoroidal blood was drained out from a PPV port. One month after surgery, the BCVA was recovered to 20/200 and the IOP was 15 mmHg. A color

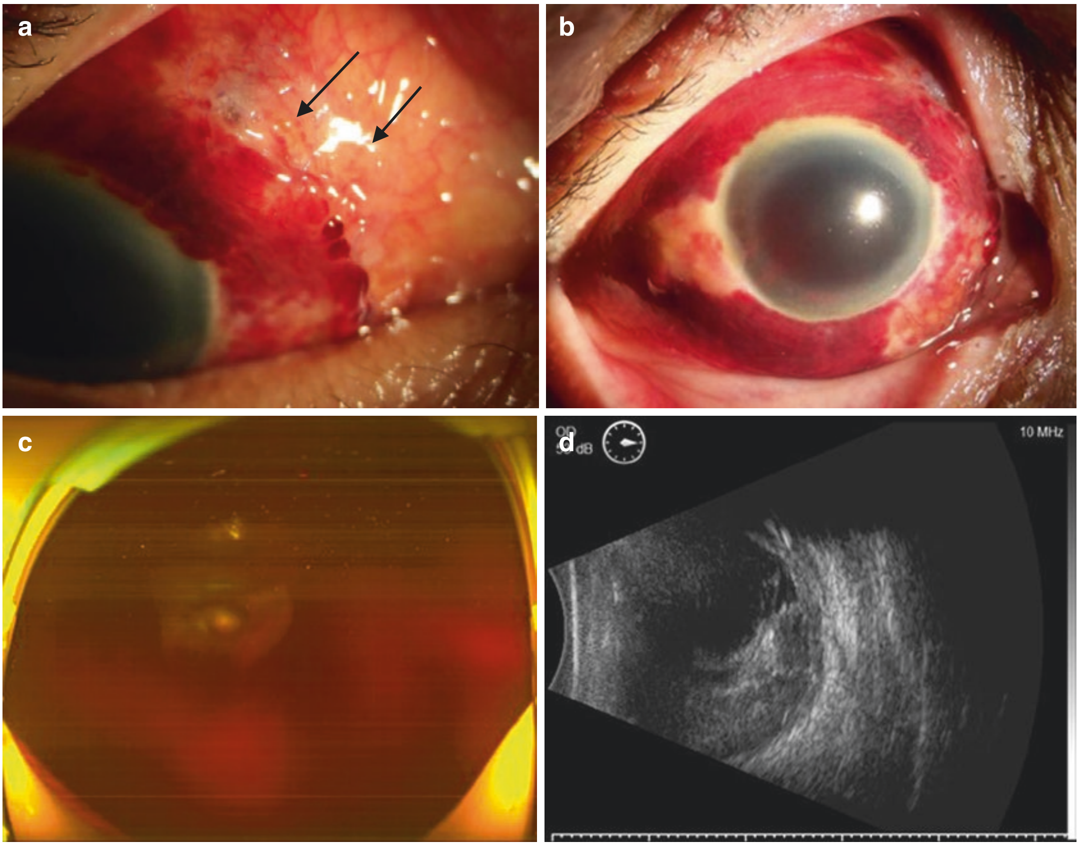

Fig. 6.25 Photographs of the right eye. (**a**) Corneal edema, absence of the lens, and (**b**) scleral laceration after repair; (**c**) vitreous hemorrhage; (**d**) and possible retinal and choroidal detachment by B-ultrasound examination. The arrow indicates the sutured conjunctival wound

fundus photograph showed a flat fundus and mild retinal hemorrhage in the former choroidal detachment place (Fig. 6.27a). Two months later, the BCVA improved to 20/100 and the IOP was 16.8 mmHg. The fundus was flat without any signs of retinal detachment (Fig. 6.27b).

6.3.7 Case #7: Vitreous Hemorrhage Because of Posterior Segment Ocular Rupture

A 51-year-old man's right eye was hurt by a car while riding an electric bicycle. The patient was sent to the local hospital in emergency, and computed tomography showed multiple orbital fractures, subarachnoid hemorrhage, optic nerve injury, and ocular rupture in the right eye (Fig. 6.28a). Orbital plasty, ocular rupture exploration, and repair were then performed at the local hospital. After 12 days, he came to our hospital for further treatment. His visual acuity in the right eye was no light perception and in the left eye was 20/20. The IOP was 5.3 mmHg in the right eye and 13.4 mmHg in the left eye. The cornea of the right eye has edema (Fig. 6.28b) and B-ultrasound examination showed vitreous opacity with retinal and choroidal detachment (Fig. 6.28c). In view of the patient's severe eye trauma and no light perception in the right eye, vitrectomy might be no beneficial. The patient and his families insist on having a try. During

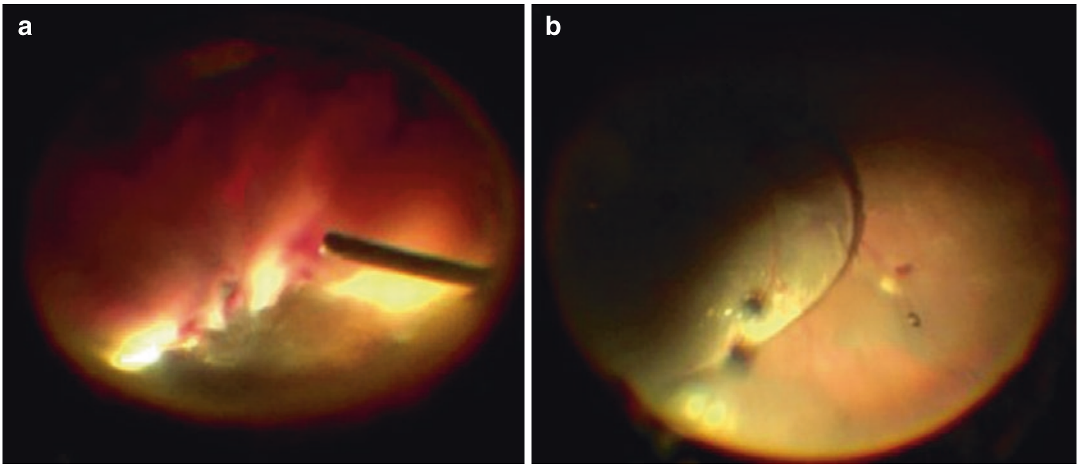

Fig. 6.26 Photographs of the fundus of the right eye during PPV. (**a**) During the operation, vitreous hemorrhage and (**b**) retinal and choroidal detachment were clearly seen. No retinal tear was found

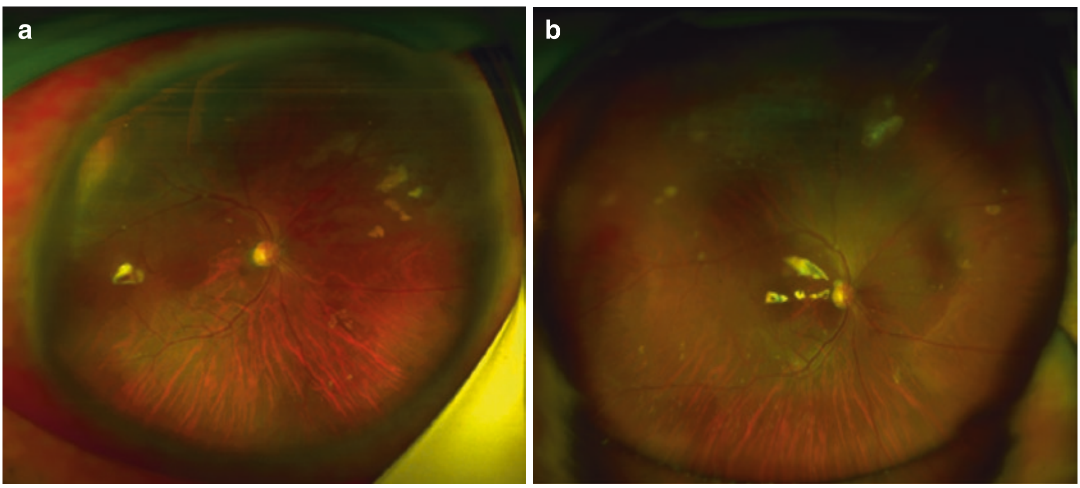

Fig. 6.27 Ocular fundus images of the patient after PPV. Color fundus photographs showed a flat fundus after 1 and 2 months. (**a**) 1 month; (**b**) 2 months

the operation, after cutting off the dislocated lens, residual flaky retina and vitreous hemorrhage mixed mass were observed. We tried to remove all the turbidity content in vitreous cavity and filled it with silicone oil (Fig. 6.28d).

6.3.8 Tips and Pearls

Open globe injury is defined as a full-thickness wound of any part of the eye. It comes in many varieties, such as blunt injury, penetrating injury, intraocular foreign body, perforating injury, and combined injury. Sharp force results in penetrating injury, an example being a nail striking the eye. Such injury may carry a favorable prognosis since the injury may be very localized. If foreign material remains lodged in the eye, it is classified as an intraocular foreign body. Ruptured globes generally occur following significant or blunt force with resultant diffuse injury, hemorrhagic choroidal and retinal detachment. Perforating

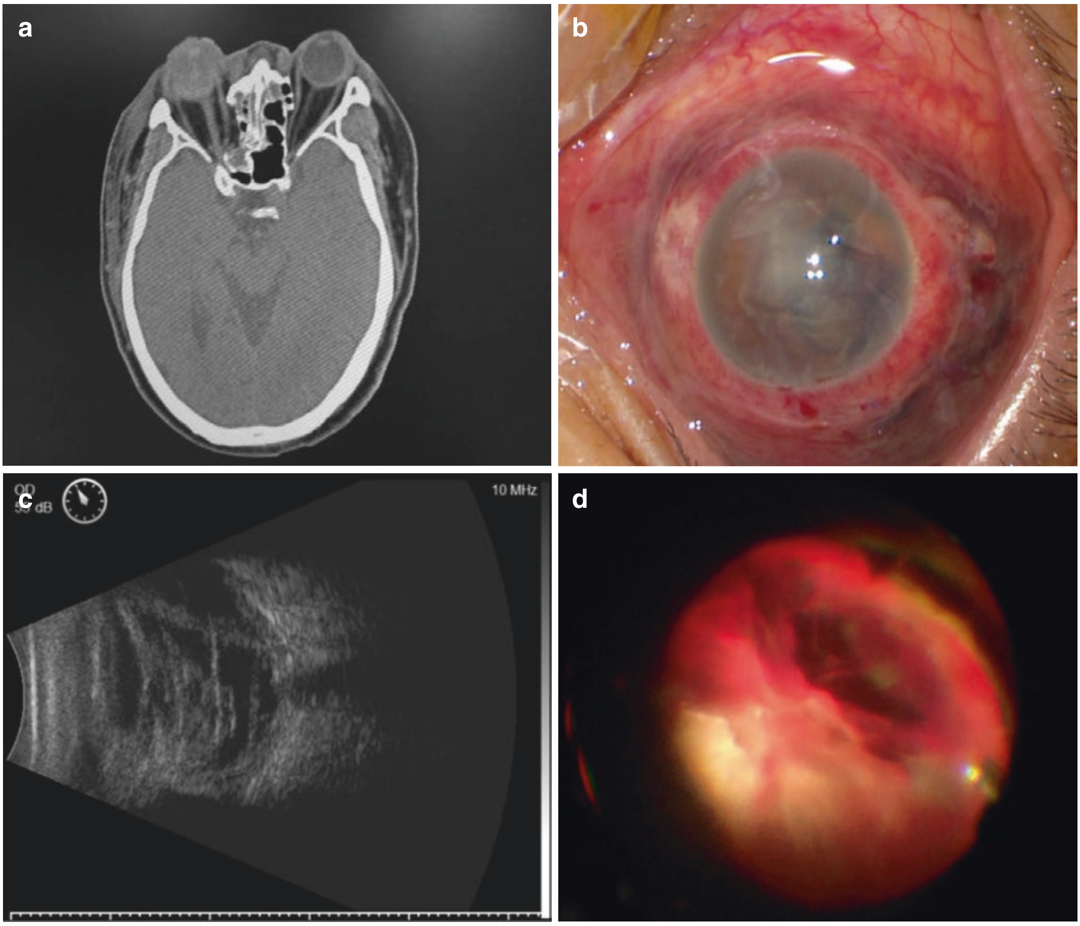

Fig. 6.28 Photographs of the right eye. (**a**) Computed tomography showed multiple fractures of the orbit, subarachnoid hemorrhage, optic nerve injury, and ruptured eye. (**b**) Anterior segment photography showed cornea edema. (**c**) B-ultrasound examination showed vitreous hemorrhage with retinal and choroidal detachment. (**d**) During the operation, residual flaky retina and vitreous hemorrhage mixed mass was observed

injury, one containing an entrance and exit wound, may carry a particularly poor prognosis since the posterior exit wound is often in the macula and may also involve the optic nerve. Obviously, a full-thickness cornea or anterior sclera wound is easy to be detected. But, in some cases, very small sharp foreign bodies can enter the eye through small wounds that are difficult to visualize or scleral wounds locate posteriorly and may be occult. Clinical suspicion should be high for the possibility of an open globe injury in all trauma cases, and complete ocular examination is important when possible.

Vitreous hemorrhage is a common complication of ocular trauma. It can occur in any kind of open globe trauma that involves the posterior segment and is always accompanied with other complications, including retinal or choroidal detachment and secondary glaucoma. If not handled properly, it may cause permanent blindness.

Management of traumatic vitreous hemorrhage is complex and varies for each individual and each trauma. Light or moderate vitreous hemorrhage without obvious complication is easy to absorb and preferred to conservative treatment. In cases of severe vitreous hemorrhage or hem-

orrhage with other complications such as retinal detachment, intraocular foreign body, perforating wound, and endophthalmitis, vitrectomy should be performed. Although controversies still exist on the timing of vitrectomy and the role of vitrectomy in open globe injuries with vitreous hemorrhage but no retinal detachment, most ophthalmologists now agree that vitrectomy is indicated for traumatic open globe injuries with retinal detachment on presentation and for perforating ocular injuries. Using an injury model with blood injection in the monkey, Cleary and Ryan were able to show that vitrectomy performed after trauma markedly decreased the incidence of traction retinal detachment [10]. Vitrectomy allows early removal of hemorrhage and treats traumatic lens, posterior segment injury, and intraocular foreign bodies. In addition, vitrectomy may reduce some complications by cleaning vitreous, cytokines and other inflammatory mediators. Finally, intravitreal pharmacological agents' injection such as triamcinolone and anti-VEGF may have potential in the management of these patients. Meta-analysis of published reports has showed that vitrectomy surgery could improve the prognosis of these diseases.

During vitrectomy, we should try to remove the vitreous hemorrhage as much as possible. Of course, complete vitreous detachment and timely laser photocoagulation for retinal tear are very important. Retinal detachment in the patient with traumatic vitreous hemorrhage can be induced by direct trauma or by traction of proliferative vitreous, which often requires several surgical operations and is associated with a poor prognosis [11, 12]. Triamcinolone acetonide staining is helpful for inducing vitreous detachment and removing it. Placing silicone oil into the vitreous cavity is a safe and effective method for patients with traumatic vitreous hemorrhage accompanied by retinal detachment.

With the advent and development of vitreous surgical techniques, our ability to deal with the open globe injury has improved tremendously in recent years. Timely and aggressive management of these injuries will offer the patient the best chances to salvage the eye and regain vision. But, in some severely injured eyes, all the efforts may be in vain and the most important thing is still ocular injury prevention.

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Retina and Choroid Injury

7

Tingkun Shi and Haoyu Chen

Abstract

Retina and choroid are located at the posterior part of eyeball. Mechanical injury to the eyeball can directly be transmitted to the retina and choroid. There are several different types of injury in retina and choroid, including choroidal rupture, commotio retinae, traumatic macular hole, retinal dialysis, epiretinal foreign body, ocular wall foreign body, and complicated retinal detachment. Ocular imaging techniques provide high-resolution images for diagnosis, understanding of the pathogenesis, and useful reference for management of patients with retinal and choroidal injury. Some of the patients required surgical intervention and some of them just need observation. In this chapter, some cases of abovementioned diseases will be discussed, with their typical imagings and management.

Keywords

Retinal injury · Choroidal injury

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7.1 Choroidal Rupture

7.1.1 Introduction

Choroidal rupture is a common finding in blunt ocular trauma when the globe is acutely deformed causing anterior and posterior compression and subsequent horizontal expansion of the eye and leading to the tear of choroid capillary, Bruch membrane, and retinal pigment epithelium (RPE) [1, 2].

During blunt ocular trauma, direct choroidal ruptures are relatively uncommon, which are located at the site of impact and tend to be parallel to the ora serrata; indirect choroidal ruptures are more common which are located opposite of the impact [2]. Most of indirect choroidal ruptures occurred temporal to the macular and leave a crescent-shaped scar concentric to the optic disc after injury.

7.1.2 Case #1

A 28-year-old man presented with pain and blurry vision in the right eye 7 days after blunt trauma. On examination, his right eye's best corrected visual acuity was 0.1. External eye examination was unremarkable. Fundus photography showed a whitish crescent-shaped lesion which involved the macula and was concentric to the optic disc (Fig. 7.1a). Spectral-domain optical coherence tomography (SD-OCT; Fig. 7.1b)

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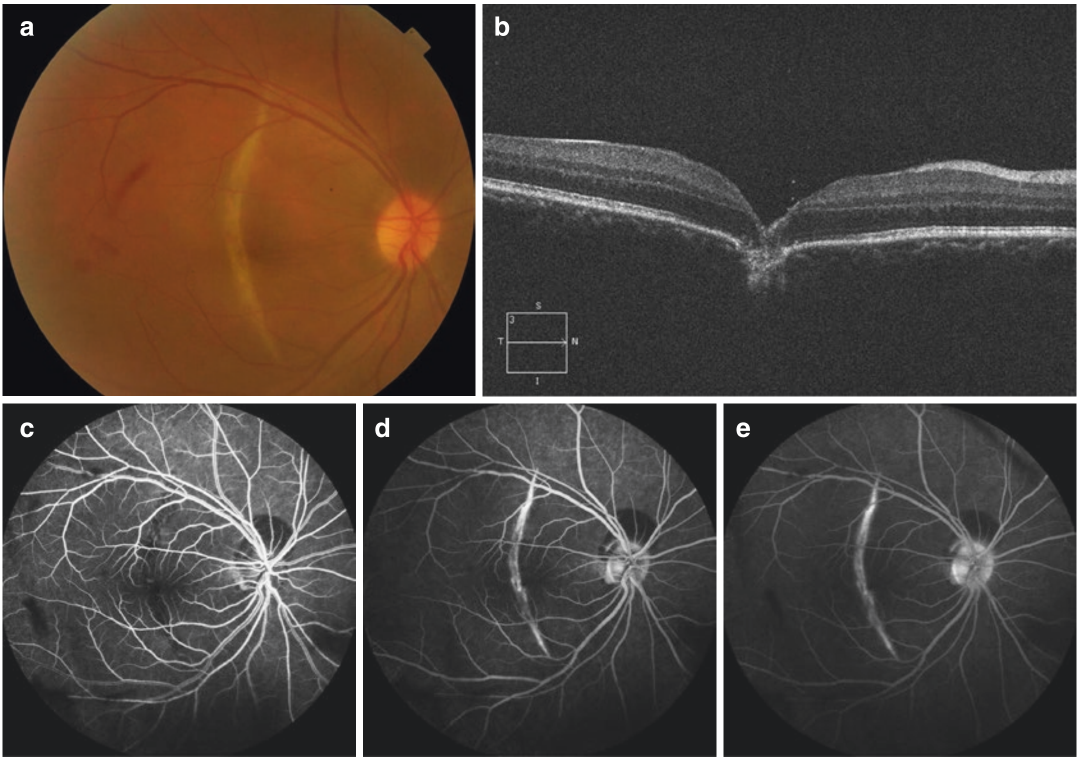

Fig. 7.1 (**a**) Color fundus photograph, (**b**) OCT image, (**c**) early-, (**d**) middle-, and (**e**) late-stage fluorescence angiography of a case with choroidal rupture

demonstrated choroidal capillary and RPE discontinuity. Retinal layers moved outward into choroid. Fundus fluorescence angiography (FFA) showed that, in early stage, the choroidal rupture lesion was hypofluorescent (Fig. 7.1c). The fluorescence intensity increased at middle and late stages, but the area of lesion did not increase, suggesting that there was staining of fluorescence but no leakage (Fig. 7.1d, e). The patient needed just observation.

7.1.3 Case #2

A 23-year-old man presented with pain and vision loss in the right eye 2 h after blunt trauma by fist. His right eye best corrected visual acuity was 0.15. There was subretinal hemorrhage at both macular and parapapillary regions (Fig. 7.2a, b). The patient was followed and the subretinal hemorrhage resolved gradually (Fig. 7.2c–h). And a 1.5 PD length streak can be found just nasal to the fovea (Fig. 7.2g). The best corrected visual acuity recovered to 0.7 at 1 year after injury.

7.1.4 Case #3

A 23-year-old female presented with vision decrease 2 months after ocular trauma at the left eye. The BCVA was 0.2. Fundus photography showed a whitish crescent-shaped lesion involving fovea and concentric to the optic disc (Fig. 7.3a). OCT showed disruption of RPE and choroid (Fig. 7.3b). There was flow signal at the outer retina in the choroidal rupture lesion on OCT angiography (Fig. 7.3c–e), and FFA showed leakage (Fig. 7.3f–i). The patient received anti-VEGF therapy and the BCVA improved to 0.5 at 1 month after anti-VEGF therapy.

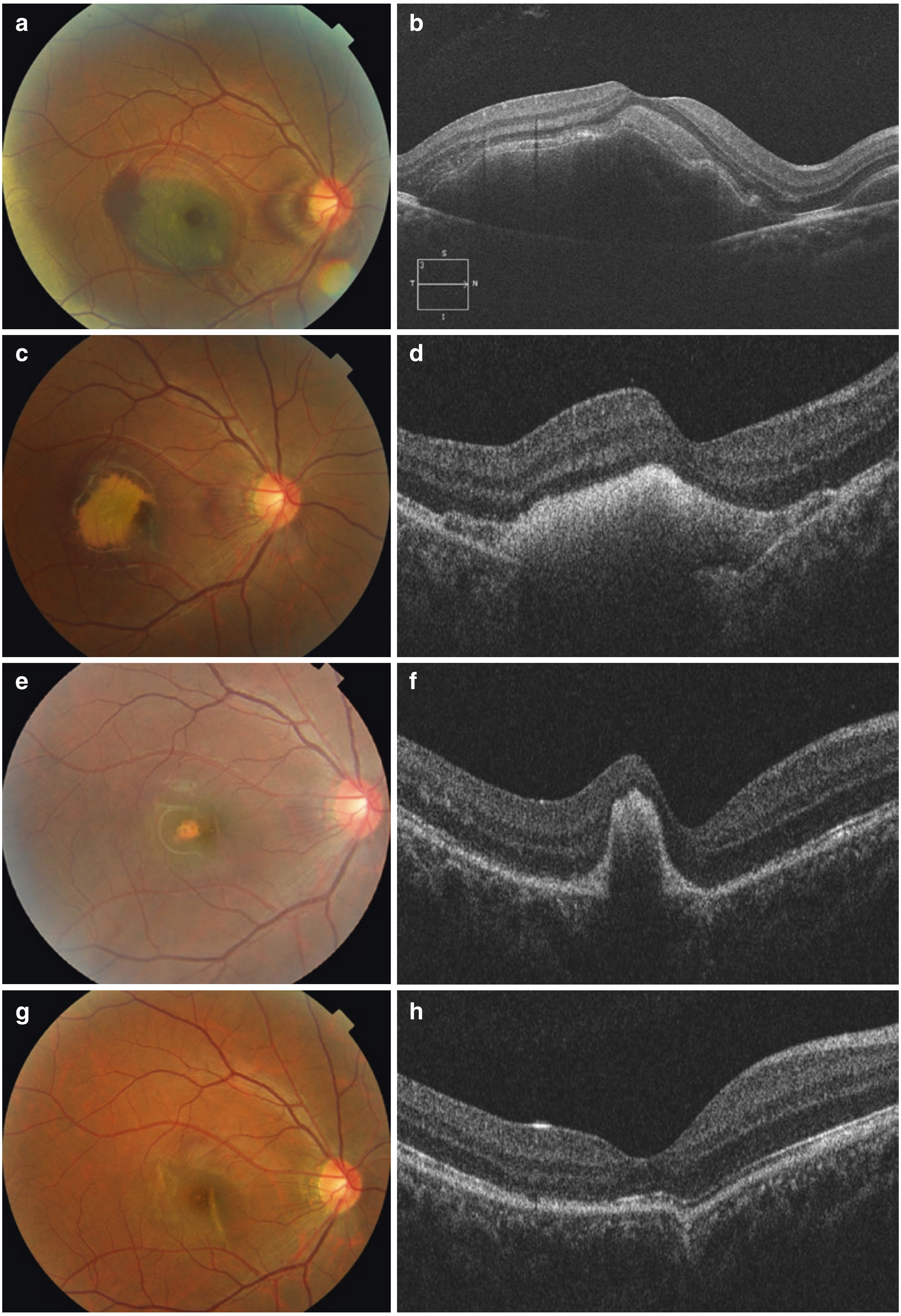

Fig. 7.2 Subretinal hemorrhage and choroidal rupture after ocular trauma. Absorption after traumatic indirect choroidal rupture. (**a**, **c**, **e**, **g**) Color fundus photography, (**b**, **d**, **f**, **h**) spectral-domain optical coherence tomography (SD-OCT) at baseline, 1 month, 2 months, and 1 year after trauma, demonstrate gradual absorption of subretinal hemorrhage over time. The corresponding best corrected visual acuity was 0.15, 0.3, 0.4, and 0.7, respectively

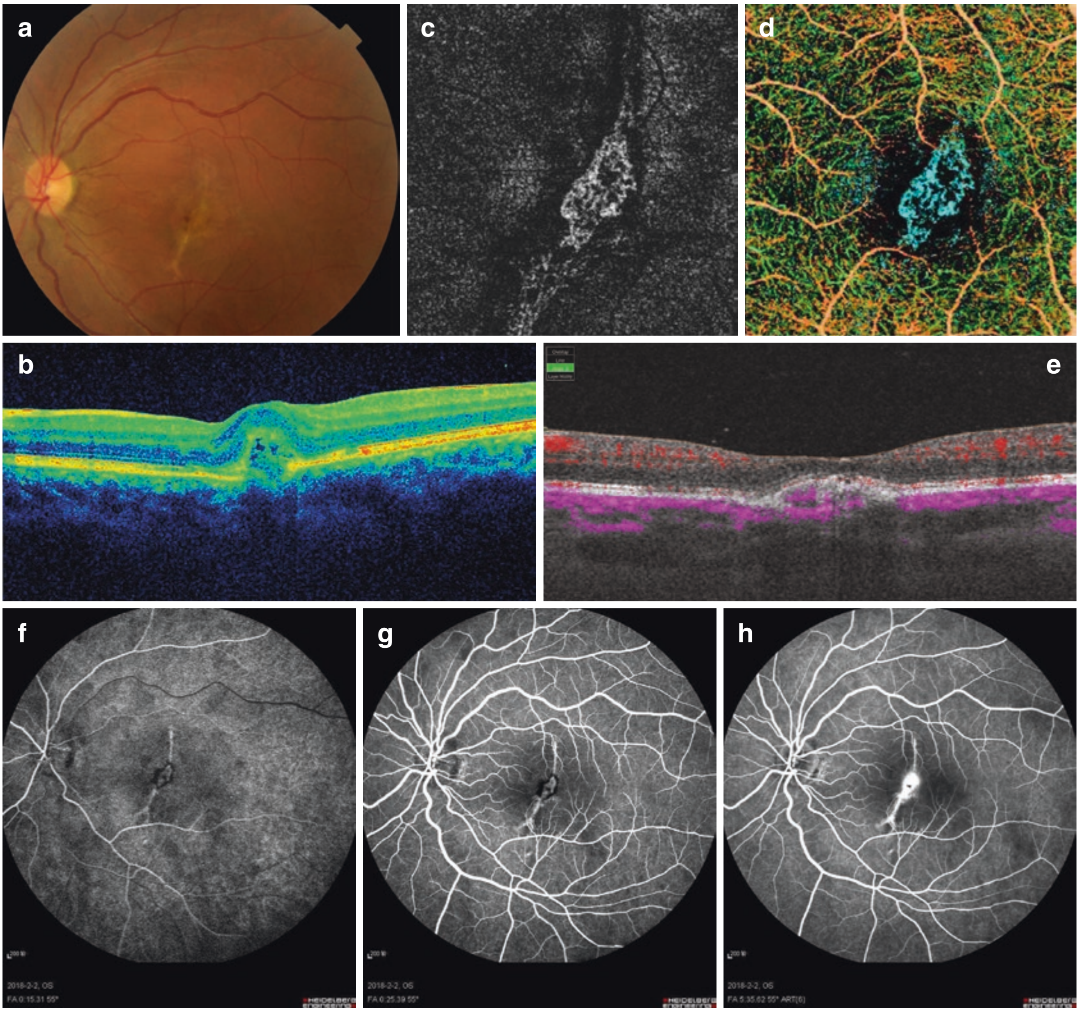

Fig. 7.3 A case developed choroidal neovascularization secondary to choroidal rupture. (**a**) Color fundus photography; (**b**) OCT; (**c**) outer retinal en face images; (**d**) merged OCT angiography of superficial capillary (yellow), deep capillary (green), and outer retina (blue) en face images; (**e**) cross-sectional OCT image with flow signal; (**f**, **g**, **h**) early-, middle-, and late-stage FFA

7.1.5 Tips and Pearls

Choroidal rupture can be easily recognized as whitish/yellowish curvilinear crescent-shaped subretinal lesion concentric to the optic disc on retinoscopy or fundus photograph. However, sometimes choroidal rupture can be hidden behind subretinal hemorrhage initiatively. Over months, after the cleaning of the blood, choroidal rupture is easily found. There may be single or multiple rupture lesions in an eyeball.

Fundus autofluorescence demonstrate hypofluorescence lesion which is caused by the break of retinal pigment epithelium. It is a good image modality for follow-up of choroidal rupture to show the healing process of choroid rupture [3]. Optical coherence tomography show disruption of retinal pigment epithelium, Bruch's membrane, and choroid. Retina usually inserts outward into the choroid wound.

Choroidal rupture can complicate with the development of choroidal neovascularization

(CNV). The risk factors of developing CNV include older age, macular location of choroidal rupture, and a greater length of the choroidal rupture. CNV can manifested as subretinal hemorrhage and exudation. It can be easily demonstrated using fluorescein angiography or OCT angiography.

No management is needed for choroidal rupture except when there is secondary CNV. Intravitreal anti-vascular endothelial growth factor is recommended for CNV secondary to choroidal rupture.

7.2 Commotio Retinae

7.2.1 Introduction

Commotio retinae, firstly called Berlin's edema, is commonly seen in closed globe trauma, characterized by the transient gray-white discoloration or opacification of retina. The term "Berlin's edema" was used to because it was proposed that the pathology of this condition is extracellular edema. However, the results of animal studies showed that the pathologic basis of commotio retinae was the damage of the photoreceptor outer segments rather than extracellular edema [4]. Optical coherence tomography (OCT) studies' results have confirmed that photoreceptor damage is the pathogenesis of commotio retinae [5–7].

7.2.2 Case #1

A 37-year-old man, presented with pain and decreased vision in the left eye half day after being hit by a basketball. On initial examination, his left eye best corrected visual acuity was 0.9. The color photograph shows that there were yellow-white discoloration changes at fovea and its nasal region (Fig. 7.4a). On OCT, there was no disruption of inner segment ellipsoid zone nor other significant change in the morphology of the retina (Fig. 7.4b). The OCT image was analyzed

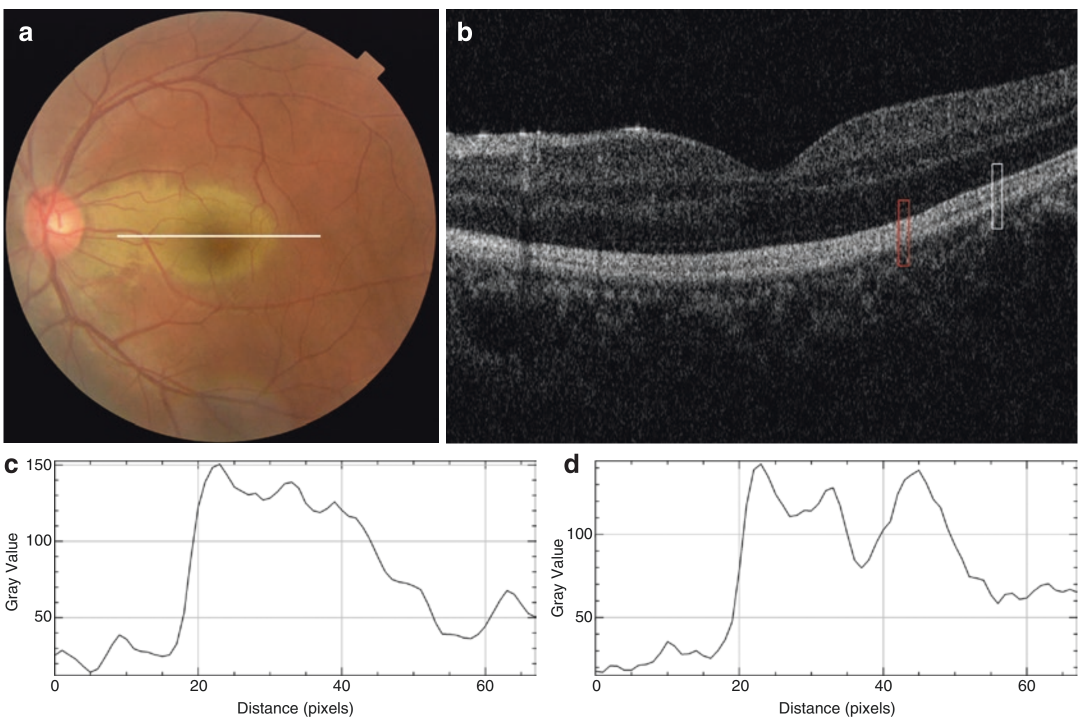

Fig. 7.4 (**a**) Color fundus photography and (**b**) OCT of a case with commotio retinae. The white line in (**a**) indicates OCT scan line for (**b**). The red and white boxes in (**b**) indicate the commotio retina and normal regions used for longitudinal reflectivity profile analysis, whose results are shown in (**c**) and (**d**), respectively

using longitudinal reflectivity profile. In the temporal region without commotio retinae, there are three peaks which are ISe, COST, and RPE (Fig. 7.4d), while in the region with commotio retinae, the troughs between the peaks are flat and short (Fig. 7.4c).

7.2.3 Case #2

A 35-year-old man visited the emergency department with pain and blurry vision in the right eye 4 h after being hit by a rock. On examination, the visual acuity reduced to 0.3 in the right eye. There was gray-white discoloration of retina inferior to the optic disc and macular fovea. SD-OCT shows disturbance reflection of ellipsoid band and RPE. The patient was diagnosed with commotio retinae and was followed-up. Two months later, the visual acuity recovered to 1.0. The gray-white discoloration of retina disappeared and SD-OCT showed smooth reflection of ellipsoid band and RPE (Fig. 7.5).

7.2.4 Tips and Pearls

Commotio retinae is characterized by loss of transparency at outer retina, which can be easily identified under ophthalmoscopy or on fundus photography. However, the whitening of retina is transient. It usually disappears at 1 week after injury. And in some cases, the whitening of retina is very mild and difficult to be identified on ophthalmoscopy and fundus photography. Optical coherence tomography can demonstrate damage

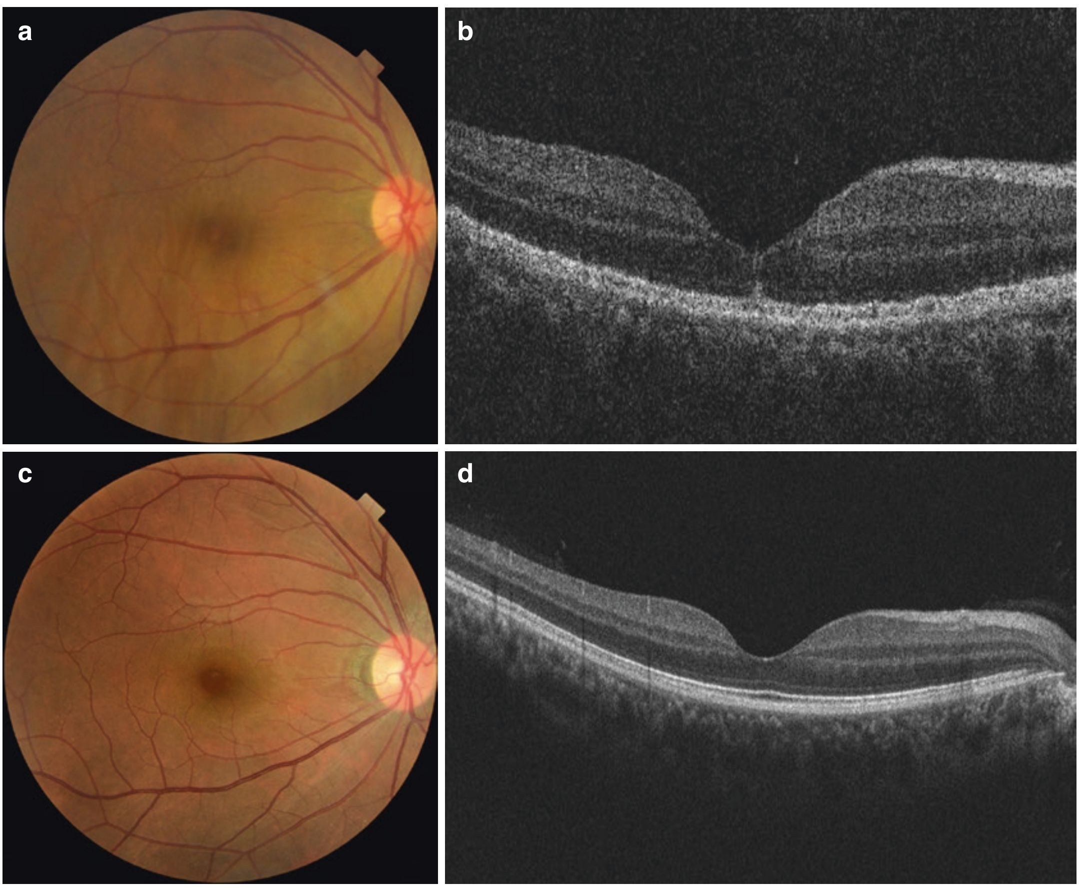

Fig. 7.5 (**a**, **c**) Color fundus photograph and (**b**, **d**) SD-OCT images of a case with commotio retinae at baseline (**a**, **b**) and 2 months follow-up (**c**, **d**)

of outer retina and be more sensitive to diagnose commotio retinae.

Furthermore, OCT can provide grading for severity of commotio retinae. An article by Ann et al. [8] reported a four-level grading system. In level 1, there is no disruption of external limiting membrane (ELM), inner segment ellipsoid zone, or outer segment tips zone but hyperreflective change of inner segment ellipsoid zone. In level 2, there is disruption of outer segment tips zone, but not in the other two zones. In level 3, there is disruption at both outer segment tips and inner segment ellipsoid zone, but not ELM. In level 4, there is disruption at all three zones. There was significant correlation between the grading and visual acuity at both baseline and follow-up. All the patients with level 1 and some patients at levels 2 and 3, but none at level 4, have normal visual acuity at last follow-up. We found that in some severer cases, there is not only disruption of outer retina bands, but also thinning of outer nuclear layer, even completely disappearance of outer nuclear layer [9]. In most severe cases, there is disorganization of inner retinal layers. Our grading system and thickness of outer nuclear layers are also correlated with visual outcome.

There is no approval of effective treatment recommended for commotio retinae, other than observation. The prognosis of patients with commotio retinae is variable. Some patients with mild injury can recover completely on morphology and visual function. But some patients may develop retinal pigment disturbance, atrophy of outer retina, and permanent impairment of visual acuity.

7.3 Traumatic Macular Hole

7.3.1 Introduction

Traumatic macular hole (TMH) is one of the major causes of secondary macular hole and can lead to severe visual loss [7, 10]. The exact basic pathogenesis of macular hole formation is controversial. But it is likely associated with a contrecoup mechanism of equatorial expansion compensatory to the acute axial compression when blunt trauma to the globe. And the expansion of posterior pole increases vitreomacular traction force [10, 11].

7.3.2 Case #1

A 24-year-old patient's right eye was injured by basketball; on initial examination, his BCVA was counting finger at 20 cm, the intraocular pressure was normal, external eye examination revealed sub-conjunctiva hemorrhage, and funduscopy examination found a full-thickness macular hole. SD-OCT and color fundus photography show a traumatic macular hole and subretinal hemorrhage (Fig. 7.6b). The diameter of macular hole was 217 μm and there was no intraretinal cyst around the hole (Fig. 7.6a). Two months later, the hole became smaller with retinal atrophy around (Fig. 7.6c, d); the hole closed spontaneously and the visual acuity improved to 20/40 at 5 months follow-up (Fig. 7.6e, f).

7.3.3 Case #2

A 20 year-old male presented with decreased visual acuity in the left eye after being injured by blunt trauma. On initial examination, the best corrected visual acuity of his left eye was 0.9 (Fig. 7.7b). SD-OCT revealed the macular hole and there was intraretinal cyst around the hole (Fig. 7.7a). The hole did not close at 6 months follow-up (Fig. 7.7c, d).

7.3.4 Case #3

A 19-year-male was referred to our unit with blurry vision in the right eye after being hit by metallic mass. On examination, his right eye best corrected visual acuity was 0.05, and the intraocular pressure was normal. Funduscopy examination and OCT revealed a full-thickness macular hole (Fig. 7.8a, b). The macular hole enlarged and there were intraretinal cysts around

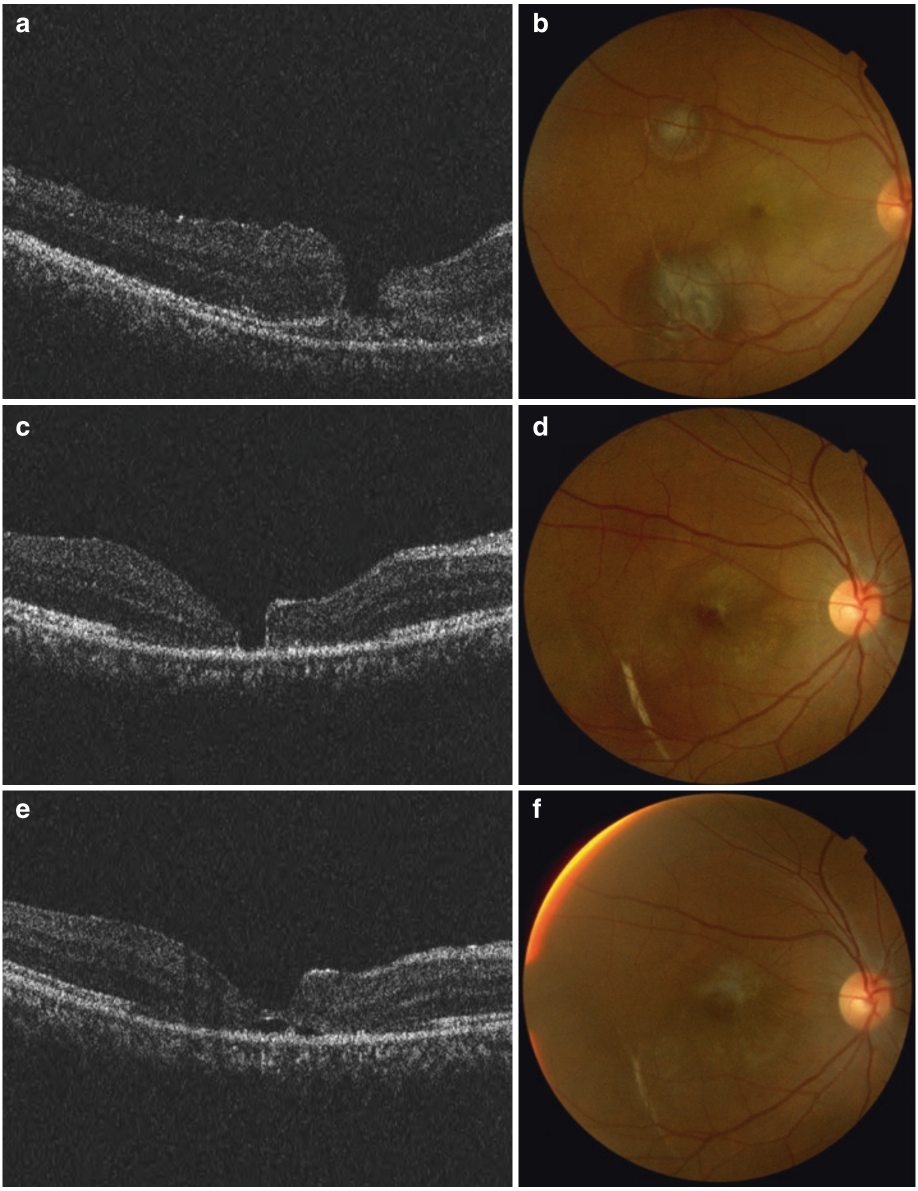

Fig. 7.6 (**a**, **b**) Color fundus photography and SD-OCT revealed a full-thickness traumatic macular hole without intraretinal cyst. (**c**, **d**) Two months later, the diameter of the macular hole became smaller. (**e**, **f**) Five months later, the hole spontaneously closed (images were adapted from Scientific Reports)

the hole at 3 months follow-up (Fig. 7.8c, d). Then the patient received vitrectomy, internal limiting membrane peeling, and C_3F_8 tamponade. The macular hole closed at 1 month follow-up after surgery and the visual acuity improved to 0.3 (Fig. 7.8e, f).

7.3.5 Tips and Pearls

It is well known that some traumatic macular hole can close spontaneously [11, 12]. The chance of spontaneous closure ranges from 10.7 to 63.6% reported in literature, with average

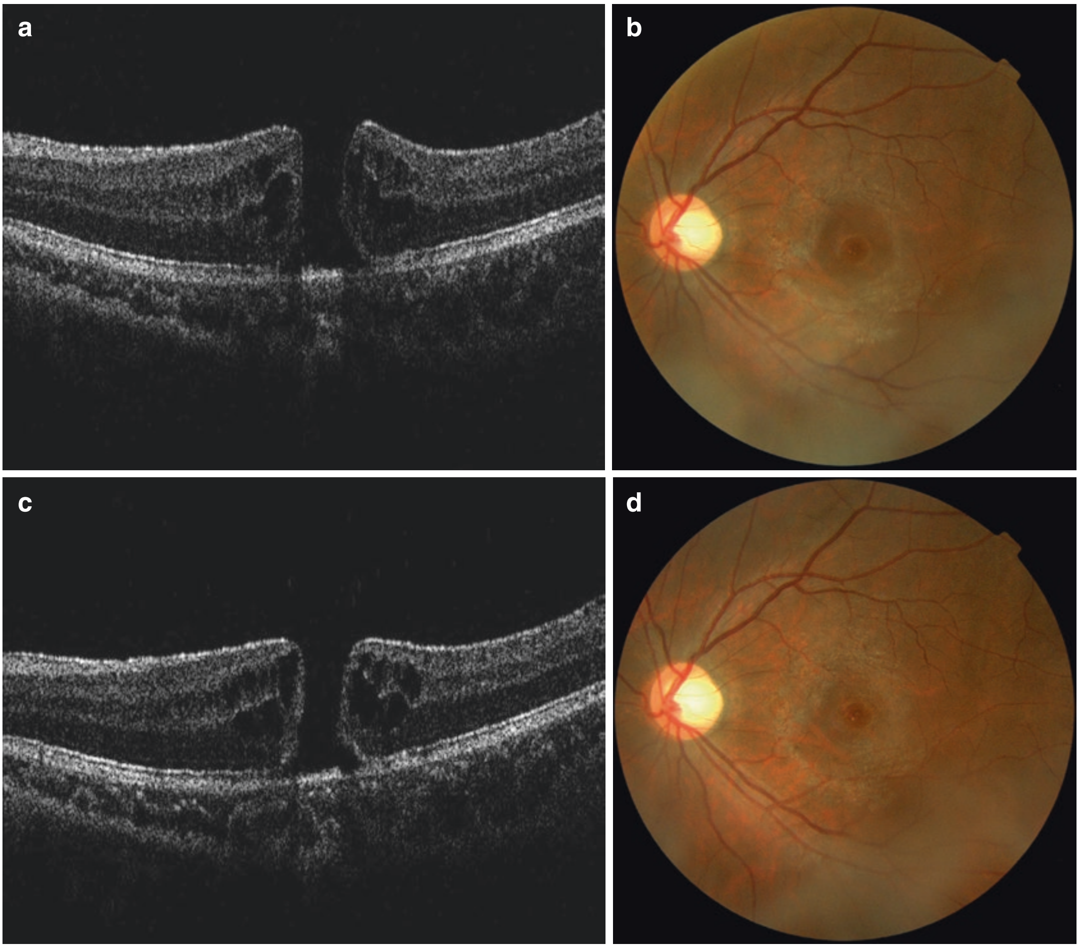

Fig. 7.7 (**a**, **b**) Color funduscopy and SD-OCT revealed a full-thickness traumatic macular hole with intraretinal cyst around the hole; (**c**, **d**) after 6 months, the size of macular hole did not change (adapted from Scientific Reports)

of 34%. It is controversial whether and when to conduct surgical management for traumatic macular hole. Spectral-domain optical coherence tomography (OCT) provides in vivo high-resolution cross-sectional images of the microstructure of retinal tissue. We have conducted a retrospective study [13] to explore whether the morphological characteristics on spectral-domain OCT can be used to predict spontaneous closure of traumatic macular holes. The results showed that more than one third of traumatic macular holes closed spontaneously in our study. Spontaneous closure of macular holes was associated with smaller minimum diameter of macular holes and absence of intraretinal cysts. Absence of intraretinal cyst is more valuable in predicting the outcome of traumatic macular hole.

For those whose macular hole cannot spontaneously closed, surgery is required. Vitrectomy and internal limiting membrane peeling was firstly used to closed idiopathic macular hole but also applied to traumatic macular hole later. The anatomical successful rate was reported between 45 and 100%. Some adjunctive therapies were used in addition to vitrectomy and internal limiting membrane peeling, including platelet concentrate, serum, etc.

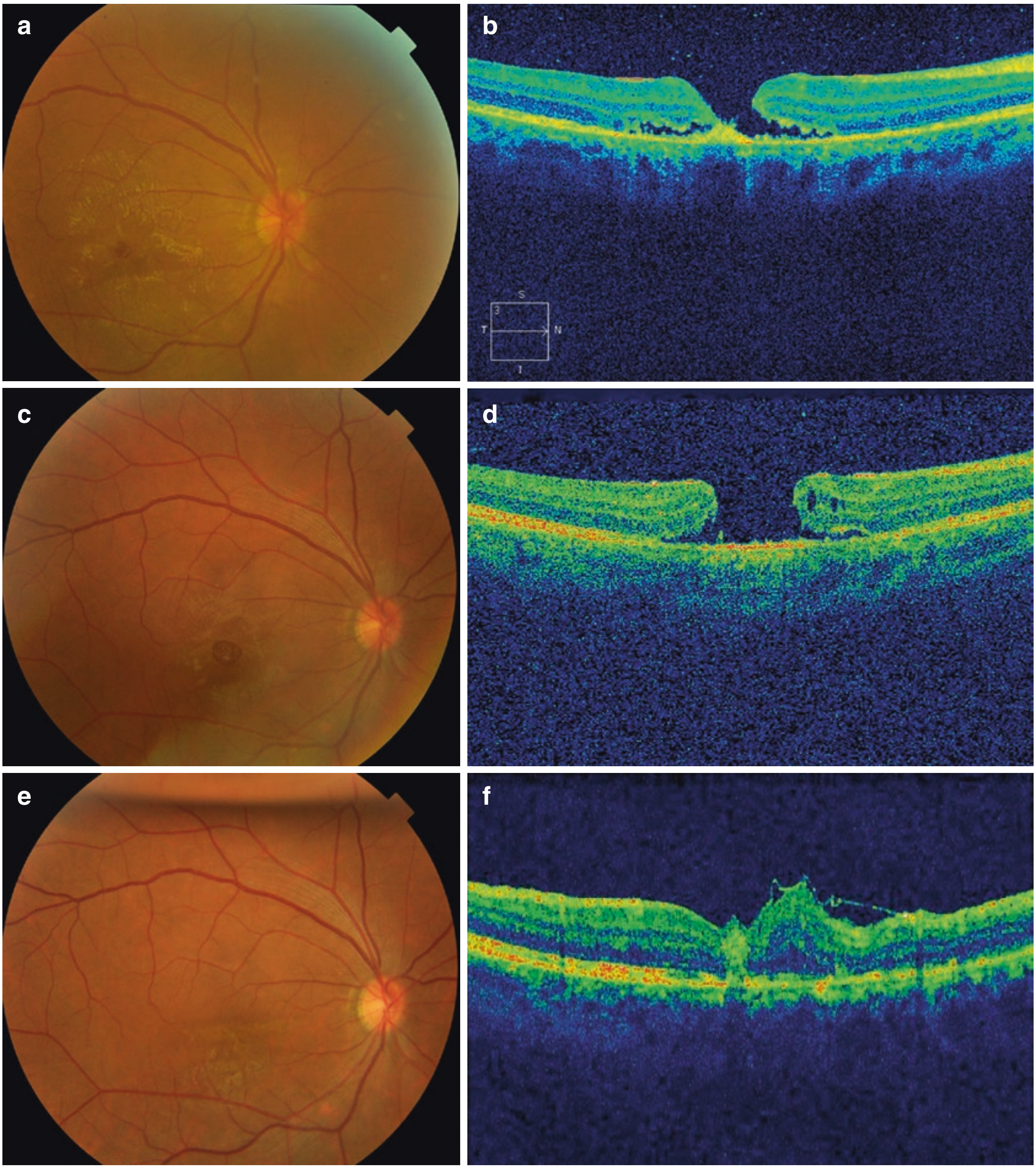

Fig. 7.8 (**a**, **c**, **e**) Color fundus photograph and (**b**, **d**, **f**) SD-OCT of a patient with traumatic macular hole at baseline (**a**, **b**), 3 months follow-up (**c**, **d**) and 1 month after operation (**e**, **f**)

7.4 Retinal Dialysis

7.4.1 Introduction

Ocular blunt trauma may lead to different types of retinal tears, such as horseshoe tears, operculated holes, macular holes, and retinal dialysis. Retinal dialysis is defined as a circumferential retinal detachment from ora serrata. It is a relatively uncommon cause of retinal detachment, accounting for 8–17% [14] of rhegmatogenous retinal detachment. Retinal dialysis most commonly occurs in young and male patient following trauma. The symptoms include visual

filed loss, gradual blurring vision, vitreous floaters, or photopsia at the time of injury or months later [14, 15]. Different to spontaneous dialysis which is most commonly located at inferotemporal quadrant, traumatic dialysis may involve all quadrant of retina [16].

7.4.2 Case #1

A 13-year-old girl presented with a sustained shadow in peripheral vision in the left eye after diving training for 10 days. Her left eye BCVA was 0.8, and the intraocular pressure was normal. Slit lamp examination of this eye did not reveal any significance. Dilated fundus examination found a retinal dialysis from 5 to 7 o'clock with inferior retinal detachment (Fig. 7.9a, blue arrows). Optical coherence tomography scan showed macular fovea was preserved from detachment (Fig. 7.9b). Segmental scleral buckling was firstly applied to fix the dialysis. After the operation, the edge of dialysis was located on the ridge of the buckle (Fig. 7.9c, blue arrows); however, a nasal part of retina was not reattached (Fig. 7.9c, green arrow). Then, pars plana vitrectomy was performed with air tamponade and endolaser photocoagulation. After the second operation, the retina was completely reattached (Fig. 7.9d) and the final BCVA was 1.0.

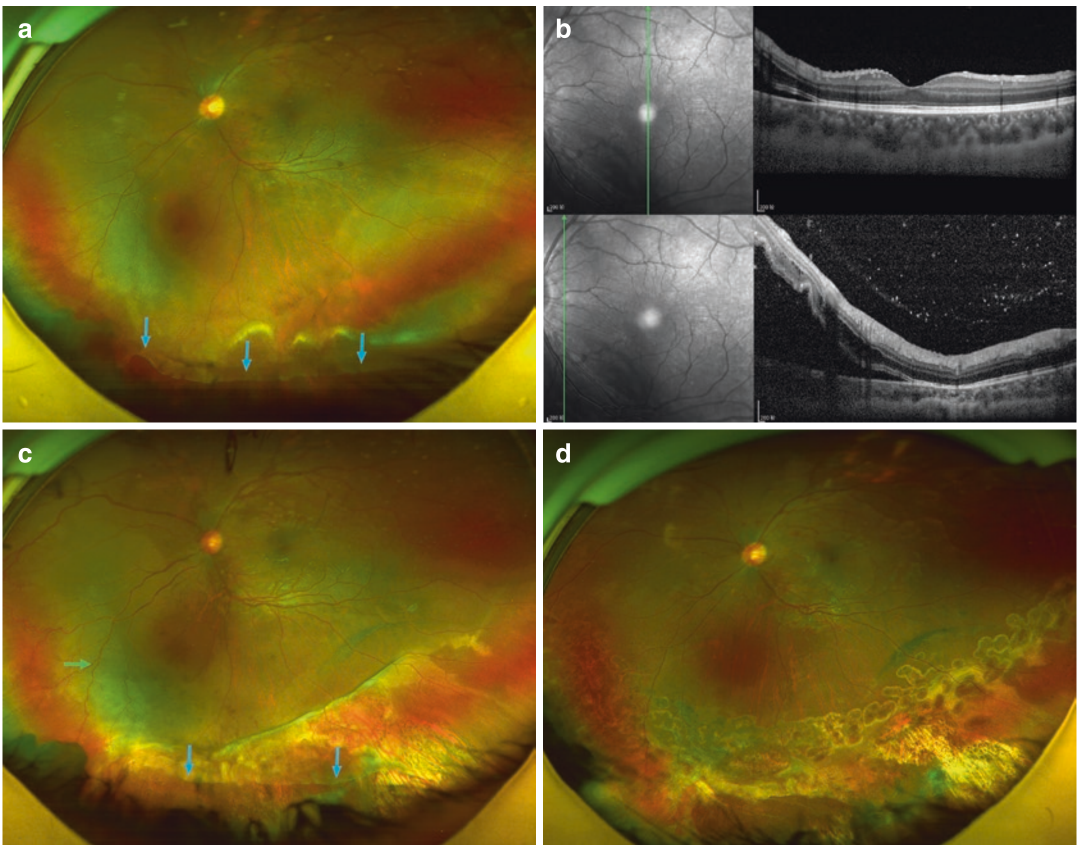

Fig. 7.9 Ultra-widefield retinal image (**a**) and SD-OCT (**b**) of a patient with inferior retinal dialysis after diving training. After scleral buckling, although the edge of dialysis was located on the ridge of the buckle (**c**, *blue arrows*), a nasal part of retina was not reattached (**c**, *green arrow*). (**d**) After vitrectomy, laser photocoagulation and air tamponade, the retina was completely reattached (Photos courtesy by Dr. Hongjie Ma and Dr. Jinglin Zhang from Guangzhou Aier Eye Hospital)

7.4.3 Case #2

A 49-year-old man presented with nasal visual field loss in the right eye for 3 days. He had history of ocular trauma in the right eye by a block 1 month before. His BCVA was 0.6 in the right eye and 1.0 in the left eye. Fundus examination revealed temporal retinal detachment and a dialysis at 10 o'clock in the right eye. Retinal detachment did not extend to macula. Vitrectomy, cryopexy, and gas-fluid exchange were performed to reattach the retina (Fig. 7.10). After operation, the retina was reattached and the final BCVA was 0.6.

7.4.4 Tips and Pearls

Retinal dialysis is located at the peripheral retina. Sometimes it is difficult to identify dialysis if there is no retinal detachment. It must be with caution that the patients with history of ocular blunt trauma may have retinal dialysis. The application of scleral indention and ultra-widefield retina imaging technique helps to find retinal dialysis.

Retinal dialysis can be treated with cryotherapy or laser photocoagulation alone if there is no retinal detachment. When retinal detachment occurs, sclera buckling and vitrectomy are both effective and safe approaches [17, 18]. It must be kept in mind that retinal dialysis may have several lesions and the lesions are usually next to each other. All round peripheral retina should be examined carefully to avoid missing retinal breaks.

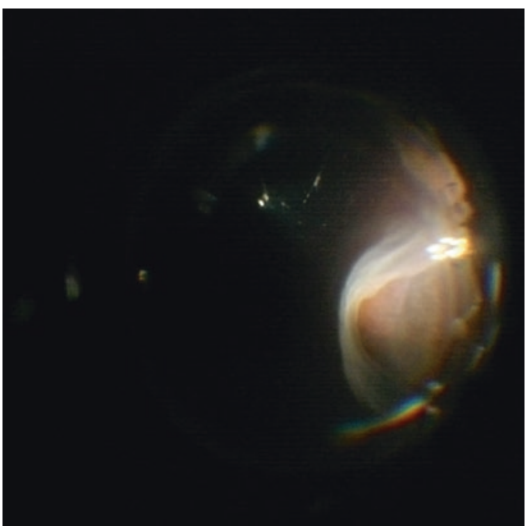

Fig. 7.10 During operation, retinal dialysis was identified under noncontact widefield lens with scleral indention

7.5 Epiretinal Foreign Body

7.5.1 Introduction

Intraocular foreign body (IOFB) accounts for 18–44% of all open globe injuries [19]. It can be classified into two types, epiretinal foreign body and ocular wall foreign body, based on the location of the foreign body in the eye. Epiretinal foreign body means that the foreign body locates at the surface of retina and there is no mechanical injury of retina.

Foreign body's injuries must be distinguished from other open globe injuries, such as penetrating injury or globe rupture, because of its unique management implications. Therefore, we should evaluate every open globe injury patient on whether an intraocular foreign body is present. The history of injury and investigations are important to detect the existence of FB; shotgun injury or hammering injury often indicates that IOFB exist in the eye. By far, computed tomography (CT) is the most important method of finding an IOFB; ultrasonography B scan and X-ray are also usually helpful.

7.5.2 Case #1

A 36-year-old male presented with pain and blurring of vision in the left eye after being hit by a brick for 1 day. On initial examination, the BCVA of left eye was 0.3 and the intraocular pressure was normal. A 1.5 mm wound was seen at the nasal cornea closed to limbus (Fig. 7.11a). The lens remained clear. Dilated examination of the fundus found a metal foreign body located on the surface of retina superior to the optic disc.

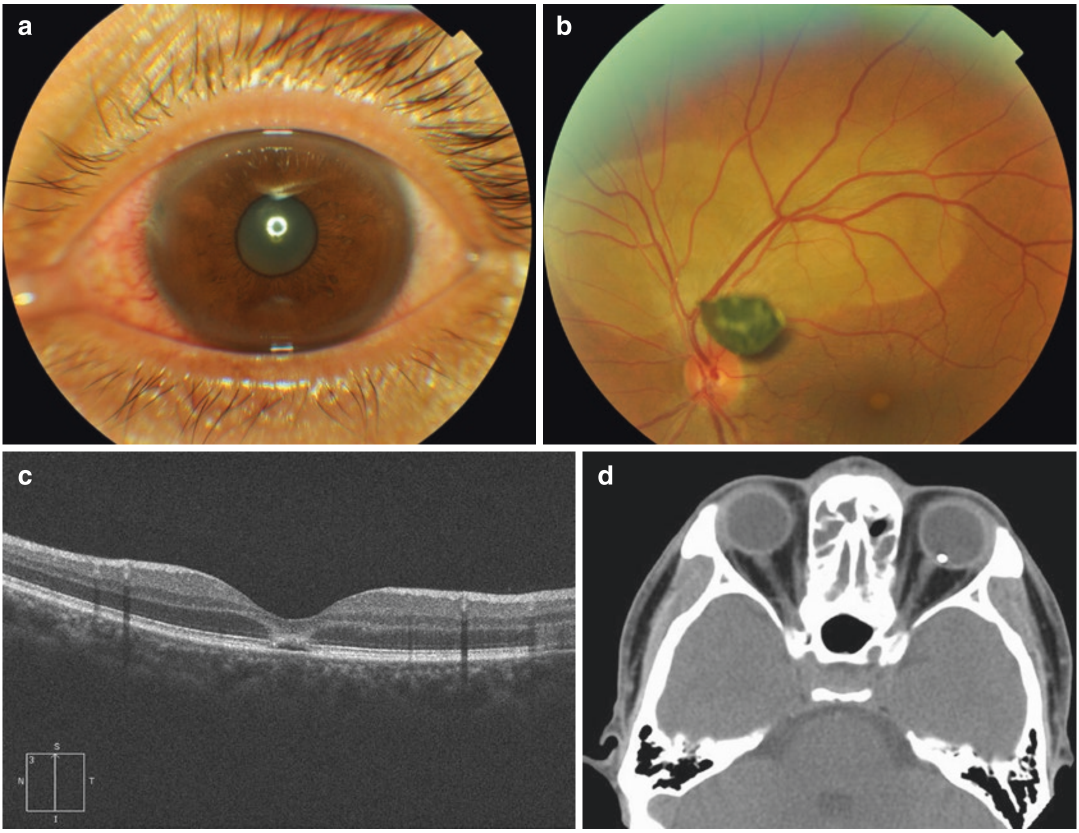

Fig. 7.11 (**a**) Anterior segment photo, (**b**) fundus photography, (**c**) OCT and (**d**) CT scan of a patient with epiretinal foreign body

The surrounding retina tissue lost transparency and appeared white (Fig. 7.11b). OCT scan of macula found hyperreflective change of outer nuclear layer at fovea and mild serous detachment of foveal retina (Fig. 7.11c). CT scan demonstrated a high-density foreign body at posterior pole temporal to the optic disc (Fig. 7.11d). The patient received corneal wound suture and pars plana vitrectomy combined with intraocular foreign body removal. And the BCVA recovered to 0.5 at 3 months after surgery.

7.5.3 Case #2

A 19-year-old male presented with pain and mildly blurring vision in the right eye after an injury sustained while hammering metal. His right eye BCVA was 0.8, and intraocular pressure was normal. Slit lamp examination of the right eye revealed a 1 mm cornea wound located at the inferior cornea. Dilated fundus examination found a metallic foreign body lying on the retina surface inferior to the macula and a 3 PD region retina with opacity (Fig. 7.12a). Ultrasound B scan found a high signal on the surface of retina with shadowing effect (Fig. 7.12b). CT scan showed a foreign body retained located inside the posterior globe (Fig. 7.12c–e). The cornea wound closed spontaneously. The foreign body was extracted using external magnet during pars plana vitrectomy, and the lesion was photocoagulated (Fig. 7.12f). The lens became opaque and the patients received cataract surgery 3 months later. The final BCVA was 1.0.

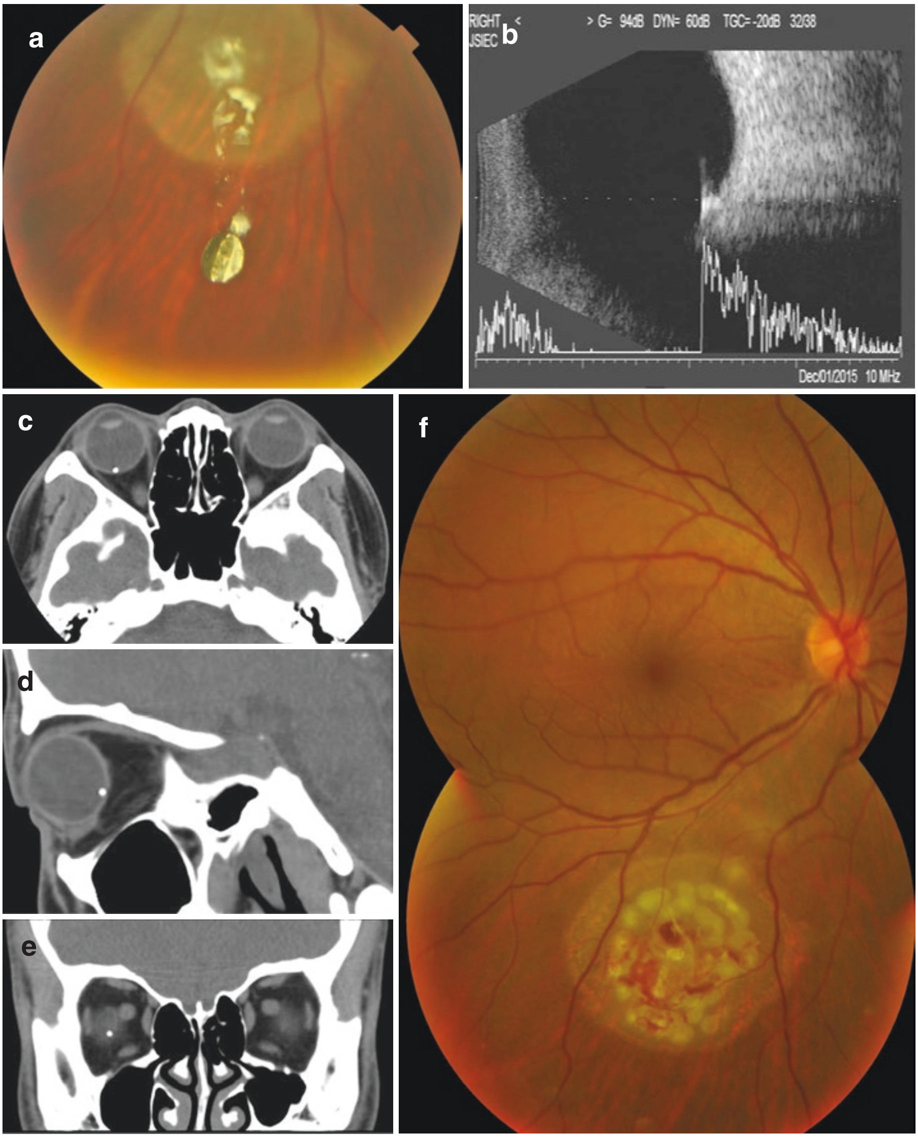

Fig. 7.12 (**a**) Color fundus photograph, (**b**) ultrasound B scan, (**c**) horizontal, (**d**) sagittal, and (**e**) coronal planes. Computed tomographic scan of a patient with epiretinal intraocular foreign body. (**f**) Color fundus photography after removal of the intraocular foreign body

7.5.4 Tips and Pearls

The diagnosis of epiretinal foreign body is not difficult with the clue of history of ocular injury and detail physical examination of the eye. In case of optical media opacity, imaging techniques such as ultrasound and CT scan can help to identify the foreign body and provide useful information of the location of foreign body, especially the relationship between the foreign body and the eyewall.

Intraocular foreign body can complicate with endophthalmitis, mechanical injury, and chemical injury. It is recommend that removal of an IOFB

should be performed as soon as possible in cases with suspected endophthalmitis [20]. It is still controversial the timing of IOFB removal in cases without endophthalmitis. Some studies' results suggest that primary wound closure by repair combined with IOFB removal reduce the endophthalmitis risk within 24 h [21, 22]. However, it was also reported that delayed removal may not substantially increase the risk of endophthalmitis [23]. In our opinion, early removal of IOFB can not only prevent endophthalmitis but also reduce the chemical injury to the retina by metal foreign body. But in some certain cases, IOFB removal must be delayed, such as lack of specialized resources or patient's systemic medical condition instability.

Pars plana vitrectomy is the most common strategy to extract IOFB. Usually epiretinal foreign body has little mechanical injury to the retina. Therefore, the surrounding retina does not need special management except laser photocoagulation. And air or gas is enough for intraocular tamponade.

7.6 Ocular Wall Foreign Body

7.6.1 Introduction

Ocular wall foreign body locates within the ocular wall. It would directly injure the retina, choroid, and even sclera mechanically. And it usually accompanies with vitreous hemorrhage. In some cases, part of the foreign body may pass through the posterior eyewall and has an exit.

7.6.2 Case #1

A 30-year-old male presented with pain and redness in the left eye after an injury sustained while grinding wheel half a day ago. His right visual acuity was 1.0 and had reduced visual acuity of 0.3 in the left eye. The diagnosis was penetrating injury and retained intraocular foreign body in the left eye. Slit lamp examination of the left eye revealed sub-conjunctiva hemorrhage temporally; anterior chamber was deep. Dilated left eye examination showed flattened retina and a deep-impact IOFB with hemorrhage at supratemporal retina (Fig. 7.13). The foreign body was removed from the sclera wound with complete vitrectomy. The retinal lesion was photocoagulated. In the next 3 months, visual acuity in the left eye improved to 1.0.

7.6.3 Case #2

A 23-year-old male presented with injury of an iron scurf 1 day ago. The BCVA was 0.4. There was penetrating injury at peripheral cornea and iris. There was a metal foreign body with size of 3 PD at inferior retina, accompanied with vitreous hemorrhage (Fig. 7.14). The patient received pars plana vitrectomy, foreign body removal, endolaser photocoagulation, air-fluid exchange, and C_3F_8 tamponade. The BCVA improved to 1.0 at the 1-month follow-up.

7.6.4 Tips and Pearls

Ocular wall foreign body posterior to pars plana is usually removed during vitrectomy via incision at limbus or pars plana. However, if the foreign body located peripherally and part of it has already penetrate the eyewall, or it is magnetic, it can be removed from sclera. But vitrectomy is still needed to remove the damaged vitreous and manage the lesion of injury on retina and choroid.

Ocular wall foreign body usually has less mobility compared to the epiretinal foreign body. Therefore, the foreign body must be freed from the ocular wall before removal. If the IOFB was surrounded by fibrous capsule, use a sharp instrument to dissect and avoid using a magnet or blunt dissection. The common complication of dissection is hemorrhage, which can be dealt with diathermy.

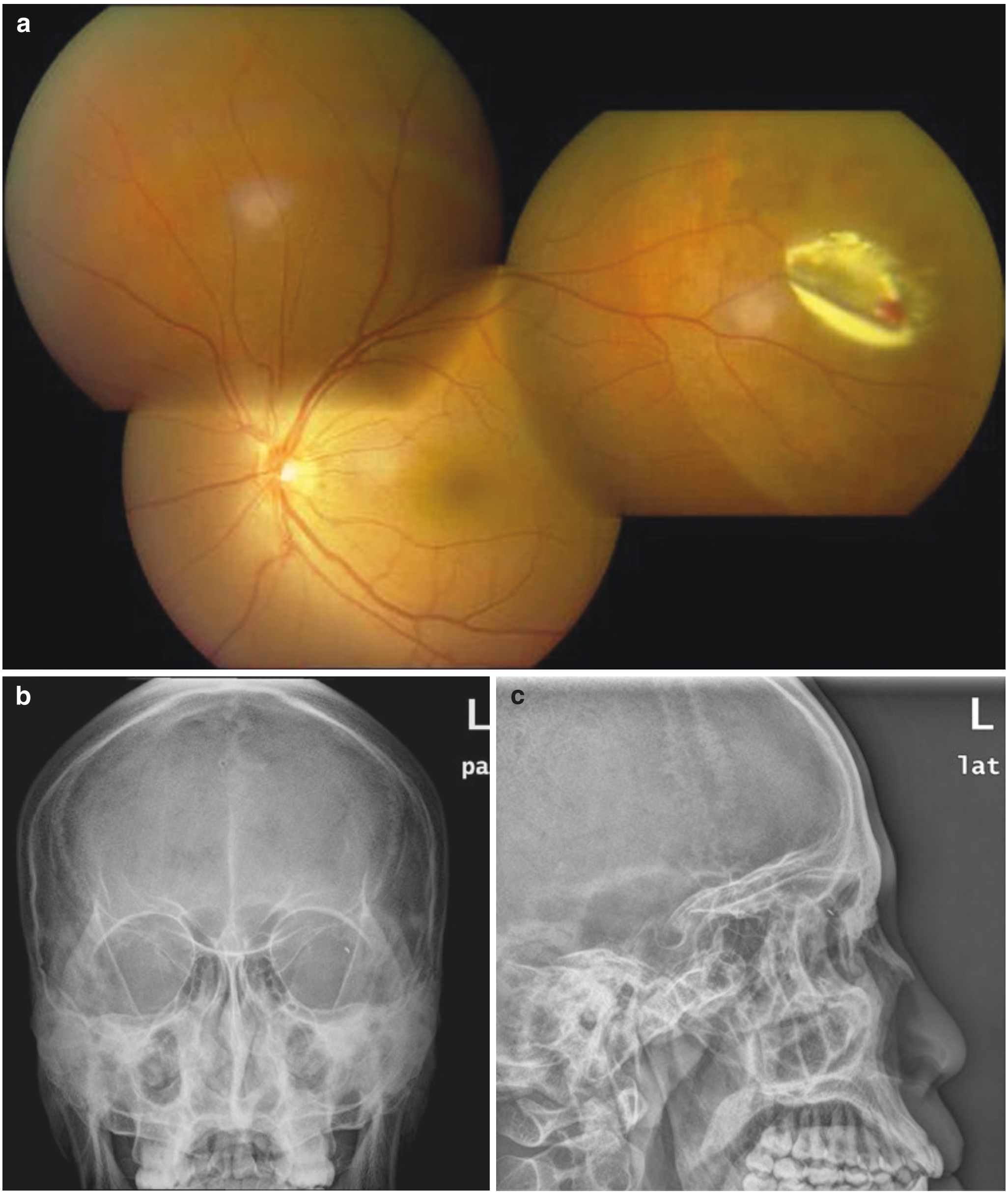

Fig. 7.13 (**a**) Color fundus photograph and (**b**, **c**) X-ray of a patient with intraocular foreign body

Ocular wall foreign body usually have mechanical injury to retina, even choroid. Therefore, it is very important to manage the site of injury. When retina is involved, laser photocoagulation must be applied to the lesion. When choroid is injured, there is high risk of proliferative vitreoretinopathy. Prophylactic chorioretinectomy is reported to prevent development of proliferative vitreoretinopathy and retinal detachment [24].

Fig. 7.14 Fundus photography showed a patient with ocular wall intraocular foreign body with vitreous hemorrhage

7.7 Complicated Retinal Detachment

7.7.1 Introduction

Retinal detachment may be secondary to closed globe or open globe injury. And most of traumatic retinal detachments are complicated. In closed globe trauma, the pathogenesis is the traction of the vitreous to the peripheral retina. Giant retinal tear and retinal dialysis may develop after blunt trauma. While in open globe injury, direct injury of retina, traction caused by massive loss of vitreous, and proliferation of vitreous may be the mechanisms of retinal detachment. Traumatic retinal detachment should be managed carefully because there is high chance of developing proliferative vitreous retinopathy (PVR).

Traumatic retinal detachment is usually accompanied with other conditions, such as traumatic cataract, vitreous hemorrhage, cornea or scleral laceration, retinal and/or choroidal injury, intraocular foreign body, and endophthalmitis. These would make the traumatic retinal detachment more complicated.

7.7.2 Case #1

A 51-year-old man was referred to our service for an emergency consultation with worsening vision in his right eye for 2 days. He had a rock injury to the right eye 1 month ago. On examination, the best corrected visual acuity was HM/30CM in his right eye and 1.0 in the left eye. Dilated fundus examination revealed vitreous hemorrhage, total retinal detachment, and subretinal gray-white proliferative fibrosis at superotemporal region (Fig. 7.15a). Ultrasound B scan also showed vitreous opacity and retinal detachment (Fig. 7.15b). The patient was treated with pars plana vitrectomy, endolaser photocoagulation, and silicon oil tamponade with successful reattachment of the retina. The retina remained attached and vision improved to 0.08 at 6 months follow-up (Fig. 7.15c). There was complicated cataract formation. The patient best corrected visual acuity improved to 0.15 after removal of oil and cataract extraction with posterior chamber intraocular lens placement at 8 months post-operation.

7.7.3 Case #2

A 69-year-old male presented for acute loss of vision in the right eye following blunt trauma with a brick. His past medical ocular history was unremarkable. On examination, BCVA in the right eye was HM/30CM and 1.0 in the left eye. External eye examination of the right eye revealed diffused edema and ecchymosis of the upper eyelid without laceration. Slit lamp examination revealed mild iridocyclitis. Dilated examination revealed a giant retinal tear from 9 to 12 o'clock. The retinal detachment extended into macula (Fig. 7.16a, b). The patient was treated with phacoemulsification, pars plana vitrectomy, endolaser photocoagulation, and silicone oil tam-

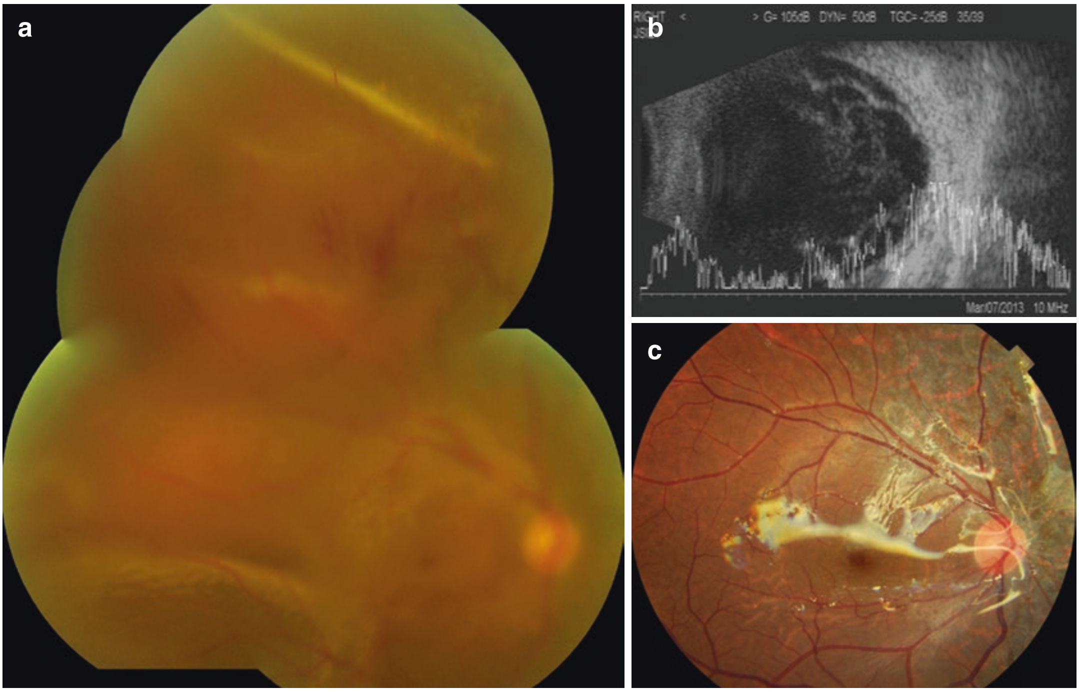

Fig. 7.15 (**a**) Color fundus photograph and (**b**) ultrasound B scan shows vitreous hemorrhage and retinal detachment after blunt trauma. (**c**) The retina was reattached after vitreoretinal surgery

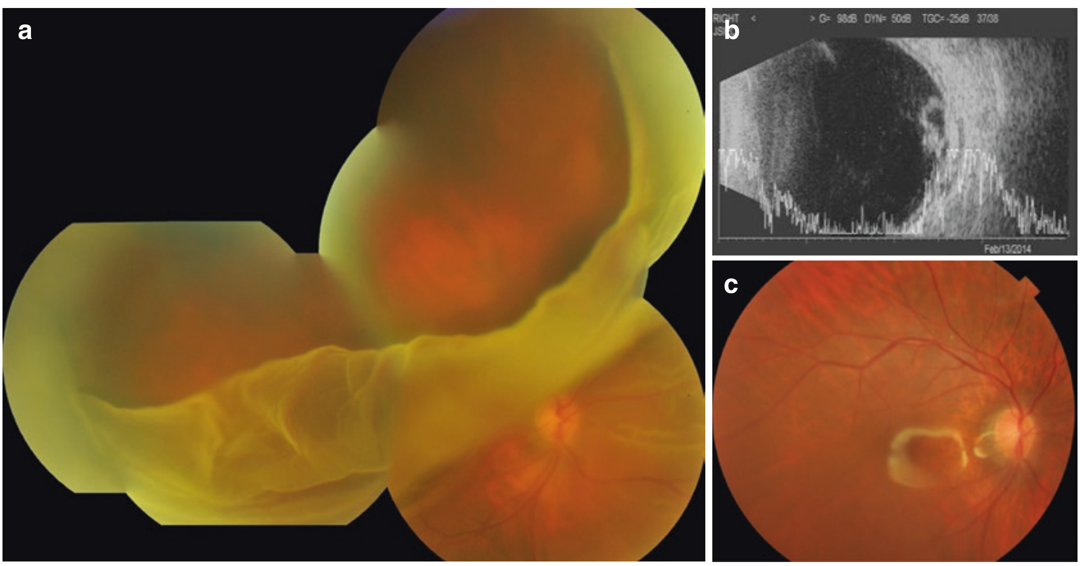

Fig. 7.16 (**a**) Color fundus photograph and (**b**) ultrasound B scan shows giant retinal tear and retinal detachment after blunt trauma. (**c**) The retina was reattached after vitreous surgery

ponade with successful reattachment of the retina. The patient best corrected visual acuity improved to 0.6 after removal of oil and implant with posterior chamber intraocular lens at 7 months post-operation (Fig. 7.16c).

7.7.4 Tips and Pearls

The time from injury to development of retinal detachment varies for days to years, depending on the location, type, and size of the break as well as whether vitreous hemorrhage or traction is present. Comprehensive assessment of the injured eye is very important. The location of the wound, possible mechanism of retinal detachment, number and location of retinal breaks, and other accompanied condition must be investigated. This would help to determine the timing and strategy of surgical intervention.

In some traumatic retinal detachment, if there is no other accompanied injury, the optical media is clear, and there is no traction on the retina, scleral buckling may be enough to seal the breaks and reattach the retina. However, in most case, vitreous surgery is required to treat traumatic retinal detachment. Careful operation to relieve all the traction and seal all retinal breaks is the key to management of traumatic retinal detachment.

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8 Eyelid Injury

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Abstract

Eyelid injuries are a common emergency room challenge due to the sharp or blunt objects, animal bites, fighting, and traffic accidents. In the treatment of eyelid injuries, especially for lacerations, it should be done properly in the first stage, which can significantly reduce the occurrence of complications and the pain caused by the second operation. This chapter includes five cases with brief descriptions, illustrating figures and personal tips and tricks, aiming to providing a guide about assessing and treating patients with eyelid trauma.

Keywords

Eyelid laceration · Contusion · Plasty Treatment

8.1 Introduction

The eyelid skin is thin, and this makes the lids prone to a dramatic accumulation of tissue fluid to cause swelling or blood to form a haematoma [1]. Eyelid injuries are frequent complications of severe trauma by blunt or sharp objects and vary in severity and extent and present in a variable fashion, such as contusion, eyelid lacerations, traumatic ptosis, canalicular lacerations, cicatricial ectropion, medial canthus deformity, and so on [2]. Eyelid lacerations are common with eyeball injuries and managed differently depending on the depth, width, and location of the injury. Surgical management will be broken down into these categories: laceration without eyelid margin involvement, laceration with eyelid margin involvement, and laceration with nasolacrimal system involvement (seen Chap. 9) [3].

The visual prognosis for eyelid lacerations is usually excellent unless there is accompanying the serious injury of eyeball. The eyelids in particular are complex structures, and repair of eyelid injuries can be extremely difficult, with the risk of ptosis when the levator muscle is involved or of unsatisfactory surgical outcome due to improper technique. With proper reconstruction of lid lacerations, the cosmetic result is usually quite good. Lid notching, cutaneous scars, and cicatricial ectropion may require revision surgery.

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8.2 Case #1: Eyelid Contusion—Subcutaneous Hematoma

8.2.1 Case Description

A 46-year-old male patient was referred to the ophthalmological outpatient department of Armed Police General Hospital of China 4 h after his right eye was injured by boxing with eyelid involvement, accompanied with pain and impaired vision. On physical examination, the right eyelid and right side of the face were very swollen, and the palpebral fissure was narrowed with a 45 × 30 × 20 mm of subcutaneous haematoma (Fig. 8.1). Ocular movements in all directions were normal, and decimal (Snellen in metres) best-corrected visual acuity (BCVA) was 0.8 (8/10) in the right eye and 1.5 (6/4) in the left eye. Intraocular pressure (IOP) was 17 mmHg in both eyes, and slit-lamp biomicroscopy showed small scattered subconjunctival haemorrhage and mild chemosis. The cornea was clear and had no epithelial defects. The anterior chamber was also clear and had no cells or flare. The pupil is round and 3 mm in diameter; light reflex is normal. The crystalline lens was normal. Fundoscopy revealed a clear vitreous cavity and a retina without abnormalities, including retinal breaks, detachment, or haemorrhage. The left eye and adnexa were completely normal. Diagnoses were right upper eyelid blunt contusion, upper eyelid traumatic subcutaneous hematoma, and blunt eyeball trauma. The patient was treated with haemostatic and cold compresses and 3 days later treated with heated compresses. One week after injury, the BCVA returned to 1.0 (6/6) in the right eye, the upper eyelid swelling subsided, and subconjunctival haemorrhage and oedema disappeared (Fig. 8.2).

8.2.2 Tips and Pearls

If the eyes are attacked by a blunt object (such as stone, stick, fist, etc.), it could result in eyelid oedema and subcutaneous hematoma, eyelid skin bruising, and eyes are hard to open. Some patients may develop eyelid subcutaneous emphysema; this is because of the eyelid contusion with medial orbital fracture, where the air goes into the eyelid tissue [4]. Subcutaneous blood stasis and emphysema in general should be absorbed by itself. The early time apply cold

Fig. 8.1 Upper eyelid hematoma after eyelid blunt injury

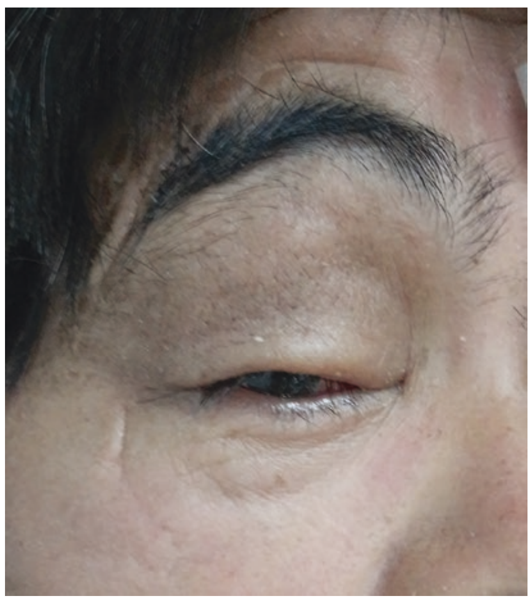

Fig. 8.2 One week after treatment of upper eyelid hematoma in the same patient

compress to control bleeding, 3 days after a hot compress should be applied, promote absorption of congestion in 1~2 weeks, will gradually return to normal absorption, if it with subcutaneous emphysema antibiotics should be used to prevent infection. The eyelid blunt trauma can be involved in the eyeball and orbit, which requires further examination.

8.3 Case #2: Eyelid Lacerations with Eyelid Margin Involvement

8.3.1 Case Description

A 33-year-old man sustained injury to the left side of the face in a traffic accident. He presented with eyelid laceration of left eye in addition to other injuries, involving the upper and lower eyelids (Fig. 8.3), with full thickness and associated with partial tissue loss, with eyelid margin involvement. The patient was taken up for examination, and performed was surgical repair under local anaesthesia. Eye examination was normal in function and extraocular muscle activity. CT scan revealed normal study of the bone and brain. The wound was thoroughly irrigated with normal saline, and tetanus toxoid was administered to the patient. Broad spectrum parenteral antibiotics were administered by injection preoperatively and continued for 3 days postoperatively. Suture of the lacerations was done in layers.

Fig. 8.3 Multiple eyelid lacerations of left eye, involving the upper and lower eyelid margins

A stay suture was inserted first at the lash margin and held by an artery clip without being tied. Once the edges of the laceration and the lid were under control, the cornea was protected by a shield, and the tarsal plate was repaired with fine soft absorbable 6/0 Vicryl, and interrupted sutures were inserted from the cutaneous side. The wound included the orbicularis but spared the palpebral conjunctiva. The suture knots were placed towards the skin, which was subsequently closed with 6/0 Vicryl. The stay suture was removed and the lid margin was sutured with 6/0 Vicryl. The grey line suture retained for 10 days. The other silk sutures are removed after about 7 days.

8.3.2 Tips and Pearls

The evaluation and diagnosis of eyelid trauma begin with a history and physical examination and observation. For injured patients, the wounds should first be thoroughly cleaned. This not only reduces the potential for infection but also permits a better view of the wounds so appropriate repair can be planned. The aim of surgical repair is to maintain function of eyelid and restore cosmesis. Primary repair should be performed as quickly as possible. Lacerations caused by animal bites, especially from dog bites, may need minimal debridement of necrotic tissue; wounds may be left open for 24–48 h for delayed repair. But primary closure is now favoured because of its better cosmetic results [5].

Eyelid lacerations may accompanied by severe eyeball injuries and retained orbital foreign bodies. Any eyeball injury should first be sought and repaired. When placing tarsal sutures, care must be taken that the suture does not penetrate through the full thickness of the tarsus; otherwise a suture-induced keratitis will develop. When orbital fat is present in the wound, an orbital injury has occurred. Prolapsing orbital fat is clamped, excised, and cauterised. Orbicular and septal lacerations in the line of the muscle fibres close spontaneously, but those at right angles will gape and are closed by absorbable sutures.

Generally, an eyelid skin laceration greater or equal to 2 linear millimetres requires repair.

Superficial eyelid laceration without eyelid margin involvement can generally be repaired with interrupted 6-0 absorbable or nonabsorbable sutures. Nonabsorbable sutures should be removed in 5–7 days. Avoid tightly tying sutures to the skin. Tight sutures can strangulate the delicate tissue. Take small bites (approximately 1 mm from skin edge) and space sutures 2–3 mm apart.

If the levator palpebrae is lacerated, the severed ends of the muscle are joined with buried long-acting absorbable sutures, the proximal end being more easily identified by upward gaze under local anaesthetic. If less than half the width of the levator aponeurosis is lacerated, it may heal spontaneously. If the levator aponeurosis is found to be detached from the tarsus, it can be repaired by suturing the cut end of the levator aponeurosis to the upper anterior face of the tarsus with either a silk or polyglactin suture. Direct repair of a cut aponeurosis or muscle is best used with 6-0 or 7-0 polyglactin suture.

If there has been loss of lid tissue, primary closure is still applicable if not more than a quarter of the lid length (a third in the elderly) has been lost, but otherwise a lateral canthotomy and mobilisation of a skin flap is necessary. If the medial end of the tarsus is avulsed, it is sutured to the periosteum behind the lacrimal crest, and the anterior part of the orbicularis tendon is sutured directly. At the time of avulsion of the medial canthus ligament, the majority of cases were combined with the canaliculi laceration, and the repair of canaliculi laceration should be sought (seen Chap. 9). The medial canthus is optimally repaired with a permanent suture fixed to the periosteum at the level of the posterior lacrimal crest.

For marginal full-thickness laceration, the goal of repair is to restore the local anatomy with alignment of the eyelid margin, tarsus, and skin. Eyelid marginal alignment is best achieved by using the eyelash line, grey line, and meibomian glands as local landmarks. The accurate alignment of the tarsal plate and the lid margin is necessary to prevent corneal or watering problems subsequently. Using 6-0 silk suture, re-approximate the edges of the eyelid margin by placing one simple interrupted suture from grey line to grey line (Figs. 8.4 and 8.5). Then, place partial-thickness simple interrupted sutures using 6-0 Vicryl to approximate edges of the tarsal plate. Tie these sutures and reflected their ends onto the eyelid skin avoiding contact with the ocular surface. This is important for the structural integrity of the eyelid. Place an additional marginal 6-0 silk suture parallel to the first but closer to lash line. The grey line suture are retained for 10 days. The other silk sutures are removed after about 5–7 days.

Fig. 8.4 Mattress suture for marginal full-thickness laceration

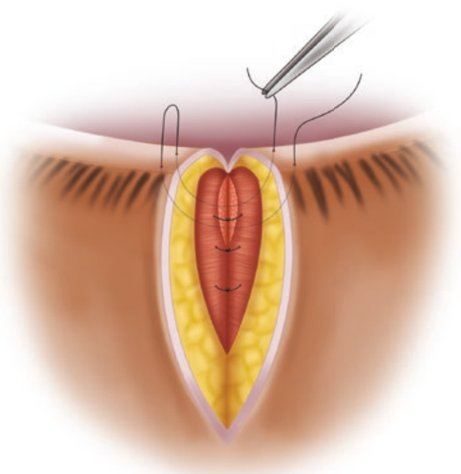

Fig. 8.5 Schematic diagram of mattress suture for marginal full-thickness laceration

8.4 Case #3: Old Eyelid Laceration with Left Medial Canthus Deformity with Lower Eyelid Ectropion—Lagophthalmus

8.4.1 Case Description

An 18-year-old man, presented with a history of traffic accident to left side of the face, complained of tearing and could not close the eye completely for 1 year. The fresh wound of the eyelid laceration has been sutured 4 years previously at another hospital. He was admitted to Armed Police General Hospital of China because of the old eyelid laceration of the upper and lower eyelids in the left eye, with the medial canthus displaced downwards and slightly lower eyelid ectropion, lagophthalmus (Fig. 8.6). The nasolacrimal system was involved and manifested the obstruction of the nasolacrimal duct and chronic dacryocystitis. Modified external dacryocystorhinostomy and the surgery of eyelids and medial canthus plasty were performed with “Z”-shaped incision approach (Fig. 8.7). The skin flaps survived without any complications, and there was good recovery of appearance and function after operation. Figure 8.8 was the postoperative view at 2 days after operation; Fig. 8.9 was the postoperative view 4 weeks after operation.

Fig. 8.6 An 18-year-old patient with a left medial canthus deformity with lower eyelid ectropion, lagophthalmus

Fig. 8.7 “Z”-shaped incision approach for eyelids and medial canthus plasty in the same patient

Fig. 8.8 Postoperative view at 2 days after operation in the same patient

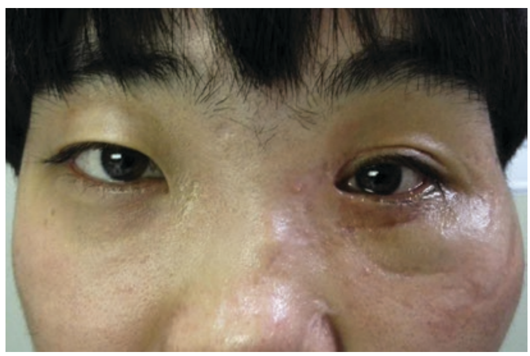

Fig. 8.9 Postoperative view at 4 weeks after operation in the same patient

8.4.2 Tips and Pearls

Eyelid lacerations involving medial canthus may be associated with a high incidence of canalicular injuries, so lacrimal system injury should be

considered when involving the medial eyelids, and attention of specialist is needed, performing careful anatomic repairs, preserving the maximum possible amount of tissue, and making liberal use of advancement flaps and postoperative skin grafts in case of risk of ectropion, lagophthalmus [6, 7]. For patients who did not receive satisfactory result in the first-stage operation after the injury, it is generally acceptable to perform a revision surgery if needed.

This patient suffered chronic dacryocystitis and obstruction of the nasolacrimal duct after trauma, and modified external dacryocystorhinostomy combined with the surgery of eyelids and medial canthus plasty was performed. In this case, it is important to restore the eyelids and medial canthus while repairing of the lacrimal drainage system. The eyelid and medial canthus deformities were addressed by a technique of Z-plasty. Z-plasty may be a simple but powerful tool to repair the eyelids and medial canthus deformity. It can be used to correct ectropion caused by injury of lower eyelids [8]. In our case, the Z-plasty on left medial canthal area contributed to elongation of the left midface and got good recovery of appearance and function after operation.

The fundamental principles in correcting the eyelid and medial canthus traumatic deformities is a precise and detailed surgical planning before surgery, and during the whole operation, attention should be paid to reduce unnecessary damage; do not apply forceps to clamp the skin margin strongly, to avoid causing a new trauma. The use of Z-shape flap plasty could not only loosen the constructed scar but also benefit in rectifying the configuration of the medial canthal area. This case reminds surgeons could perform a combined surgery of eyelid and lacrimal passages successfully during a single procedure.

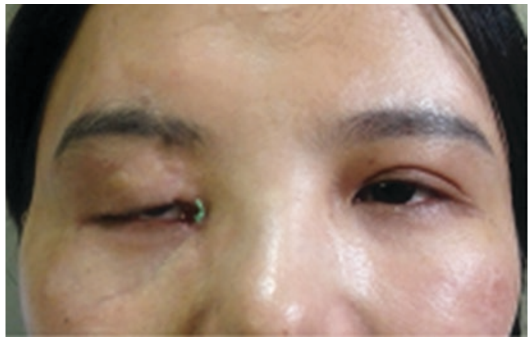

Fig. 8.10 Ptosis of upper eyelid after laceration in right eye

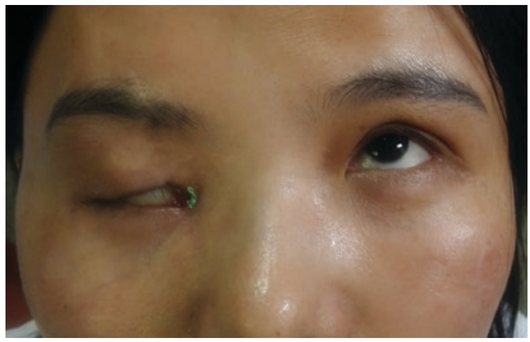

Fig. 8.11 The upper eyelid cannot be lifted up when the patient is looking upwards in the same patient

8.5 Case #4: Traumatic Ptosis After Eyelid Lacerations

8.5.1 Case Description

A 34-year-old woman was admitted to our unit with a chief complaint of difficulty in opening of right eye for 11 months since a traffic accident. She presented ptosis of upper eyelid, lagophthalmus, medial canthus deformity, and absence of inferior punctum with obstruction of superior canaliculi of right eye (Fig. 8.10). Diagnosis of traumatic ptosis was made on the basis of local examination of the eye which shows drooping of the upper eyelid, no voluntary opening of right eye, and no levator function (Fig. 8.11). Visual acuity was normal and pupils were reactive. The patient was taken for the surgical correction of ptosis under general anaesthesia.

8.5.2 Tips and Pearls

Traumatic ptosis is not an uncommon consequence of eyelid trauma. Lacerations or contusive trauma may lead to traumatic ptosis [9].

The ptosis may persist for a variable period of time and often resolves spontaneously for up to 6 months after injury. The initial treatment for traumatic ptosis, which has been caused by contusion, is observation. It is not unusual to see complete recovery 6 months following the accident [10–12]. If full recovery does not occur, exploration of the eyelid and repair of the ptosis are indicated. The initial repair of a traumatic ptosis requires a careful and layered lid repair.

The treatment of choice for post-traumatic ptosis correction depends upon the levator muscle function and condition of tarsal plate. There are three methods of surgical correction of ptosis: levator resection surgery, Muller's muscle resection, and frontalis sling operation [13]. In the case of adequate levator muscle function, if it is possible to identify levator muscle and the tarsal plate is intact, suturing the tarsal plate with levator aponeurosis will be enough to give desired result. If the levator function is poor, then frontalis sling operation will be the better choice [14] (Fig. 8.12).

Some of the complications which can be seen are as follows: under-correction, overcorrection, inability to close the eye, suture abscess, eyelid hematoma, injury to eyeball, and lid lag in downward gaze. Proper understanding of upper eyelid topography and careful assessment of muscle function will result in appropriate selection of operative procedure with good result and minimum morbidity.

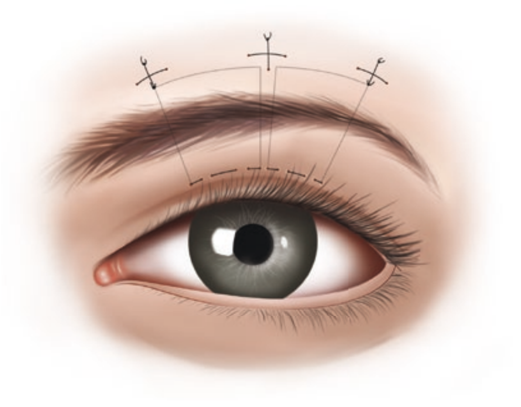

Fig. 8.12 Schematic diagram of frontalis sling operation with suture

8.6 Case #5: Eyelid Defect with Lower Eyelid Ectropion After Eyelid Lacerations Involved Lacrimal System

8.6.1 Case Description

A 32-year-old woman was admitted to our unit with a chief complaint of tearing of left eye since 2 years after a traffic accident. She presented lower eyelid ectropion, medial canthus deformity, and absence of inferior punctum of the left eye. The medial canthus appears as rounded configuration (Fig. 8.13). Visual acuity was normal and pupils were reactive. Ophthalmic examination shows the superior canaliculi had soft stop at 3 mm from the lacrimal punctum and could not be broken through with a probe. So traumatic deformity of medial canthus, lower eyelid ectropion, absence of inferior punctum, and old laceration of superior canaliculus were diagnosed. After admission, the reversion surgery was performed, in which the reversed shape of "Z" incision was made, the lacerated superior canaliculus was repaired with inferior punctoplasty, and eyelid and medial canthus were reconstructed with the pedicled flap transposition (Fig. 8.14) at the same time. The skin flaps survived without any complications, and there was good recovery of appearance and function after operation. Figure 8.15 was the postoperative view at 3 days after operation; Fig. 8.16 was the postoperative view 3 months after operation, where the appearance was improved significantly. Six months after operation, the superior and inferior canaliculi were unobstructed, and no recurrence was found after 1 year follow-up.

8.6.2 Tips and Pearls

Traumatic eyelid partial defect is one of the common complications of eyelid laceration, often because loose eyelid tissue was more serious, although after the primary repair, but could not be fully restored, the patients generally requires revision surgical treatment.

If the defect is small and the skin lax, primary closure with undermining of the adjacent skin

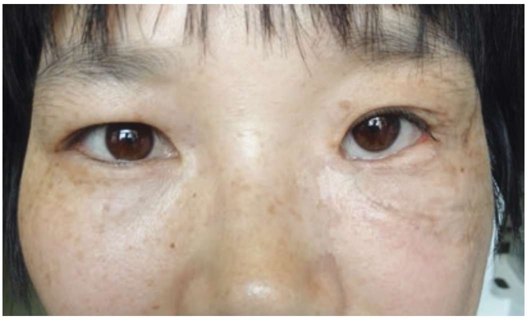

Fig. 8.13 A patient with lower eyelid partial defect and medial canthus deformity in the left eye 2 years after laceration

Fig. 8.15 Postoperative view at 3 days after operation in the same patient

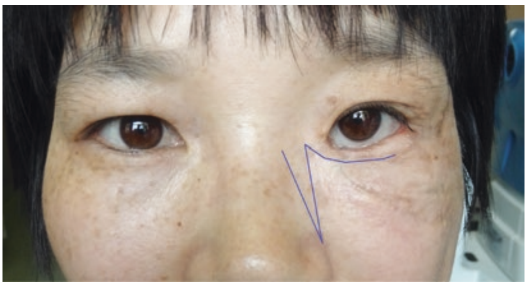

Fig. 8.14 Reversed shape of Z incision approach for eyelids and medial canthus plasty in the same patient

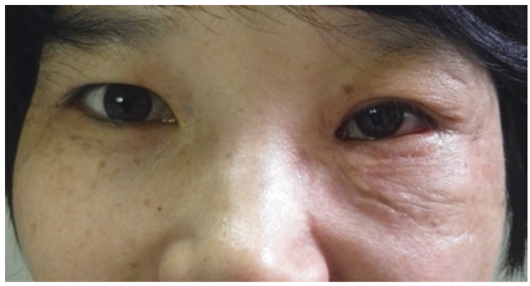

Fig. 8.16 Postoperative view at 3 months after operation in the same patient

and orbicularis is ideal. In patients with defects involving less than one third of the lower eyelid, the Tenzel rotation flap, the sandwich technique, and the adjacent tarsoconjunctival flap combined with skin graft could be performed [15, 16]. The lacrimal system should be taken care of while excising and reconstructing the medial canthal lid. The superior canaliculi and inferior punctum were involved in this case; canaliculi and punctum were repaired with bicanalicular intubation first, avoiding damage to the canaliculi with stent as landmark.

Reversed shape of Z-plasty plays the same role as Z-plasty in case 3. Lower eyelid ectropion and the rounded configuration of the medial canthus corrected by this technique show it is an ideal technique for restoring both function and appearance of the eyelid, medial canthus, as well as lacrimal system in a single procedure.

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9 Lacrimal Apparatus Injury

Hai Tao, Xibin Zhou, and Yueyue Li

Abstract

Lacrimal apparatus injuries include lacrimal gland injuries and lacrimal duct injuries. The lacrimal gland is located in superior-temporal orbital region, is fixed in the hard orbital rim, and is not easy to be damaged; otherwise, the canaliculus, which is one part of the lacrimal duct, is the right part that its injury is one of the most common types of ocular trauma in clinic. This chapter includes six cases with brief descriptions, illustrating figures and personal tips and pearls, aiming to provide a guide about diagnosis and management of lacrimal apparatus injury.

Keywords

Lacrimal gland injury · Lacrimal duct injury · Canalicular laceration · Diagnosis and management

9.1 Introduction

The lacrimal apparatus is the physiological system containing the orbital structures for tear production and drainage. It consists of the lacrimal gland, which secretes the tears, and the lacrimal duct by which the fluid is conveyed into the cavity of the nose. Lacrimal apparatus injuries include lacrimal gland injuries and lacrimal duct injuries. The lacrimal gland is almond-like and can be found along the superolateral segment of the orbit; under normal circumstances, the lacrimal gland is fixed in the hard orbital rim, not easy to touch and also not easy to be damaged. Lacrimal duct trauma can be divided into bony lacrimal duct trauma and membranous lacrimal duct trauma, bone lacrimal duct injury including lacrimal fossa, and bony nasolacrimal duct injury. The membranous lacrimal duct consists of punctum, lacrimal canaliculus, lacrimal sac, and nasolacrimal duct. Theoretically, any part of the lacrimal apparatus may be damaged, but clinically lacrimal duct injury is one of the most common types of ocular trauma in clinic. The causes of lacrimal trauma can be divided into two categories, mechanical and nonmechanical, of which mechanical injury is more common in clinic. According to the different injury materials, mechanical injury can be divided into two categories, sharp injury and blunt injury; instruments that caused sharp injuries include knife, scissors, bullets, nails, animal claws and teeth, etc. The objects of blunt injury include the fists, sticks, stones, wardrobes, or table corners. Nonmechanical injuries of lacrimal apparatus mainly include chemical burn, thermal burn, radiation injury, etc., but it is rare in clinic.

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This chapter focuses on mechanical injury to the lacrimal apparatus.

9.2 Case #1: Acute Lacrimal Gland Abscess Secondary to Lacrimal Gland Contusion

9.2.1 Case Description

A 24-year-old man was admitted to the Lacrimal Apparatus Center of the Armed Police General Hospital of China for there were red and swollen, painful subcutaneous mass in the upper eyelid after its temporal side boxing injured for 14 days. Fourteen days ago, the patient was boxing injured on the temporal side of the upper eyelid and superior orbital rim of the right eye. The skin of the eyelid became red and swollen, painful subcutaneous mass (Fig. 9.1), but there was no skin opening wound. One week before admission, the symptoms were aggravated, and the mass was obviously larger than before; the patient then went to the outpatient department of our hospital to see a doctor. The diagnosis is blunt contusion of the lacrimal gland in the right eyelid with secondary lacrimal gland abscess. The visual acuity of right eye was 10/10 (Snellen chart), the upper eyelid skin redness, pain, presented acutely with an enlarging, painful mass in the superior-temporal area. The mass size was about 50 × 30 × 20 mm, compression pain was obvious, and there was a sense of fluctuation. The upper eyelid drooping cover the cornea, and the patient was difficult to open the eye, the eyeball position and movement as usual, the skin of lacrimal sac region without red and swollen. Slit-lamp microscopy: conjunctiva congestion, corneal transparency, the anterior chamber was normal, KP (−), Tyndall's sign (−), iris color was normal, and pupil size about 3 mm in diameter with normal reflection of light. The fundus was normal, and the intraocular pressure was 19 mmHg (non-contact tonometer, Topcon CT-8). Clinical examination, echo graph, and surgical evaluation review a lacrimal gland with abscess, which was treated with oral antibiotics in combination with incision, draw, and marsupial injection. He recovered well after surgery, and when the condition was significantly reduced and the patient was discharged from the hospital, the upper eyelid mass in the right eye of the patient disappeared obviously, and the skin incision healed. Follow-up for 2 years showed good appearance and no recurrence (Fig. 9.2).

9.2.2 Tips and Pearls

Because the lacrimal gland location is hidden in the hard orbital rim, the lacrimal gland injury was rare. Lacrimal gland contusion due to traumatic touch or blunt blow, external force conduct through the frontal bone and hurt the lacrimal gland, called lacrimal gland contusion. In general, the adjacent tissues such as the eyeball, the orbital wall or optic nerve may be involved by more serious damage, such as the eyeball inury, orbital fracture, or optic nerve injury. The main damage of lacrimal gland is rupture due to compression, and it may be prolapsed or have cyst in

Fig. 9.1 Secondary lacrimal abscess after contusion of lacrimal gland in the right eye

Fig. 9.2 Postoperative view at 6 months after operation in the same patient

lacrimal gland in late stage. In adults, if accompanied by eyelid skin sagging, due to orbital septum and lacrimal gland fixation and ligament relaxation, slight contusion can cause lacrimal gland prolapse.

Lacrimal gland abscess after blunt contusion of the eyelid and superior orbital rim was rare. There have been reports on traumatic lacrimal gland abscess, one of which is secondary lacrimal abscess with intracranial infection after acupuncture treatment and recovered after incision and drainage and antibacterial treatment. Typically, lacrimal gland ductal cysts developed after chronic inflammation, infection, or trauma. Eifrig reported a patient who presented acutely with a lacrimal gland ductal cyst associated with a rare complication of abscess formation [1]. Lacrimal gland ductal cysts are rare, but must be considered in the differential diagnosis of lacrimal gland and upper eyelid mass lesions.

In this case, lacrimal gland abscess occurred after boxing injury to the upper eyelid and lacrimal gland. It was speculated that the abscess may be caused by the wound of lacrimal gland tissue or lacrimal excretory duct; secondary cyst and purulent bacterial infection then occur, although there was no opening wound on the skin surface. About treatment, mainly incision and drainage, and antibiotic use, most patients have a good prognosis.

9.3 Case #2: Lacrimal Gland Fistula Secondary to Lacrimal Gland Laceration

9.3.1 Case Description

A 9-year-old girl [2] was referred to ophthalmology department for clear fluid discharge from a cutaneous fistula for 1 week. She had an operation history for frontal bone fracture (without meningeal or cerebral involvement) secondary to severe head trauma by a goat 3 weeks earlier. From the hospital records, the initial trauma had also caused skin laceration in the left superior orbital rim, and it had been sutured. However, suture rejection and wound dehiscence had been observed 5 days after the initial trauma. The patient underwent a detailed ophthalmological examination. There was no restriction in eye movements. Visual acuity was 10/10 (Snellen chart) in both eyes; Schirmer's test, anterior segment, and fundus examinations were normal. However, the orifice of the discharging cutaneous fistula was observed in the mediolateral portion of the superior orbital rim (eyebrow), which had been previously sutured, and has been detected to have an increase in serous secretion with emotional stimuli and irritation of the left eye (Fig. 9.3). In the left frontal region, "C"-shaped cicatrix of the skin incision (traumatic and sur-

Fig. 9.3 The photograph was captured immediately after irritation of the left eye with penlight. The big white arrow shows the orifice of the lacrimal gland fistula in the left superior orbital rim, and the small white arrow points out a teardrop, which was leaked [2]

gical) was noted. Orbital computerized tomography and magnetic resonance imaging findings were nonspecific. An experienced neurosurgeon examined the patient. There was no active cranial pathology, and serous secretion from the fistula was not considered as cerebrospinal fluid (CSF). During the preoperative preparation of fistulectomy, the fistula was self-healed and symptoms disappeared.

9.3.2 Tips and Pearls

In the current literature, a number of studies reported lacrimal gland injuries and fistulas [1–4]. In 1980, Putterman firstly presented a child with epiphora secondary to lacrimal gland fistula, but it was not concluded whether it was congenital or traumatic [3]. In recent years, formation of lacrimal gland fistula following eyelid surgery was reported in several studies. In the current report, the clinical characteristics of a child with lacrimal gland fistula following severe head trauma by a goat are very rare conditions. Furthermore, congenital misdirected lacrimal gland ductules were described by Cogen et al. [4]. López Muñoz D reported a case of lacrimal fistula, which resulted in a large amount of permanent exudates flowing out due to trauma. The mechanism of hyperfunction caused by perforation of the gland capsule was not clear. A small amount of alcohol was injected into the acini near the rupture of the capsule, so that the gland function was completely restored to normal and there was no recurrence of fistula [5].

In the present case report, a unique case with discharging lacrimal gland fistula following severe frontal trauma by an animal was described. It should be kept in mind that superior orbital and frontal trauma could lead to lacrimal gland injury and secondary fistula. Skin wounds in this region should be carefully explored and well closed.

Iatrogenic lacrimal gland injury is the other most cited cause of the lacrimal gland fistula. Kashkouli et al. report the first case of lacrimal gland fistula after upper eyelid blepharoplasty for blepharochalasis. The patient underwent upper blepharoplasty and levator resection. Upper blepharoplasty included skin-orbicularis muscle flap excision, medial fat excision, and partially preaponeurotic fat excision through a hole in the center of the septum. She had an uneventful postoperative follow-up with the exception of lateral hooding of the right lid. An elliptical lateral hooding excision was performed 2 months after upper blepharoplasty. At 1 week post-hooding excision, there was wound dehiscence with clear watery drops discharging from the wound (Fig. 9.4). A palpable lacrimal gland was found at the wound site. The patient was scheduled for repair of the wound and repositioning of the lacrimal gland. There was a tract from the lacrimal gland to the skin of the upper eyelid at the site of wound dehiscence. The lacrimal gland was repositioned into the lacrimal gland fossa using 4-0 prolene suture. The fistula tract was resected and the wound was closed. The postoperative course was uneventful during the last visit at 6 months after repair [6].

Ahn et al. [7] presented the formation of lacrimal gland fistula after upper eyelid surgery: a 34-year-old woman underwent lateral canthoplasty twice of both eyes with additional upper eyelid surgeries; after the cosmetic lat-

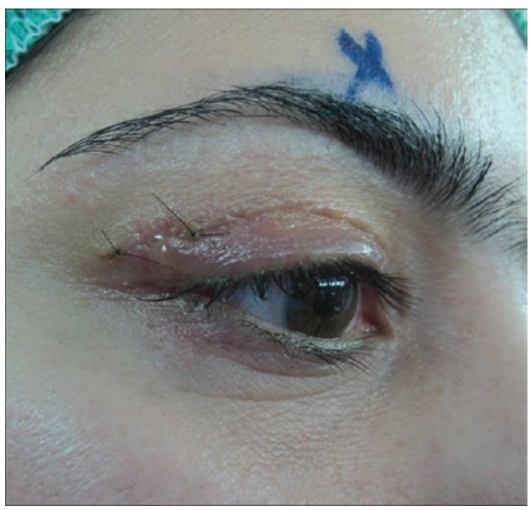

Fig. 9.4 Post-lateral hooding excision right upper eyelid wound dehiscence and watery drops show a fistulous tract from lacrimal gland to the wound [6]

eral canthoplasty, clear liquid was drained from a small drainage tract near the lateral canthus. The tract was differentiated from the lacrimal gland using a Bowman probe, and a lacrimal gland fistulectomy was performed; the discharge was resolved, leaving no complications. Beyer-Machule et al. [8] reported a case of severe ptosis with tear fistula after repeated resection of the levator palpebrae superioris muscle. The fistula was excised and pathologically traced to an accessory lacrimal gland. Leelapatranurak reported four patients who experienced tearing from a lacrimal ductule fistula after cosmetic lateral canthoplasty [9].

These cases serve as a reminder for surgeons performing these procedures that they should be aware of lacrimal gland herniation and fistula tract formation, especially in patients who have undergone multiple eyelid surgeries.

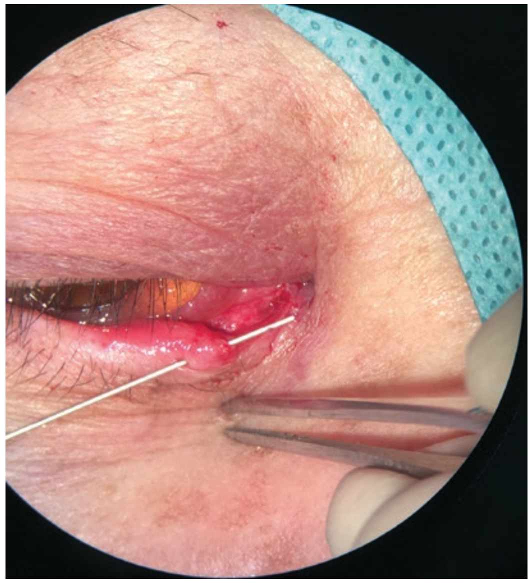

Fig. 9.5 Laceration of the lower eyelid and the lower lacrimal canaliculus and penetration of the probe from the lower lacrimal punctum to the temporal cut end

9.4 Case #3: Laceration of Inferior Canaliculus

9.4.1 Case Description

A 68-year-old woman suffered a laceration in the lower eyelid of her right eye due to an inadvertent fall, accompanied by bleeding and tears for 25 h. She was diagnosed as having "laceration of the inferior lacrimal canaliculus in the right eye" in a local hospital and was transferred to the Lacrimal Apparatus Center of the Armed Police General Hospital of China for treatment because of limited conditions in the local hospital. She was admitted to the emergency department of the hospital with "laceration of the inferior lacrimal canaliculus in the right eye." Eye examination: right eye visual acuity was 8/10 (Snellen chart). Intraocular pressure: Tn. There was a 6-mm-long oblique laceration of the eyelid, and laceration of the inferior lacrimal canaliculus (Fig. 9.5) occurred near the medial canthus of the lower eyelid. The lower lacrimal punctum was displaced and everted with the laceration of the lower eyelid. There was no restriction in eye movements. Probing and irrigation of lacrimal passage: the lower lacrimal canaliculus was lacerated, and the temporal cut end of the lower lacrimal canaliculus was about 5 mm away from the lower lacrimal punctum. The upper lacrimal canaliculus was normal. Conjunctival congestion and edema, corneal transparency, and fundus examinations were normal. Diagnosis: (1) laceration of the lacrimal canaliculus in the right eye and (2) laceration of the skin in the lower eyelid in the right eye. Under local anesthesia, the nasal cut end of the inferior lacrimal canaliculus was detected under the operating microscope (Fig. 9.6), the anastomosis of the inferior lacrimal canaliculus in the right eye and the debridement and suture of eyelid laceration were performed, and bicanalicular intubation with silicone tube stent was undergone by the patient (Fig. 9.7). Postoperative infection prevention, symptomatic treatment, wound healing well 3 days after surgery, and sutures were in place (Fig. 9.8). The patients with left lacrimal canaliculus cut end and eyelid skin laceration healed well, lacrimal stents in place when she was discharged. The lacrimal stent was removed 3 months after operation, the wound healed, and the appearance recovered well (Fig. 9.9).

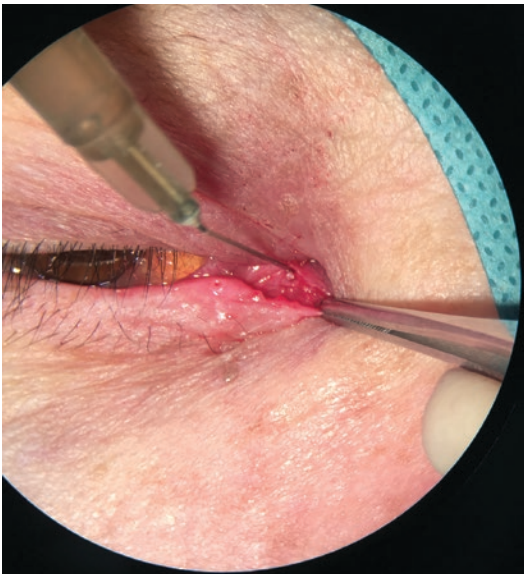

Fig. 9.6 Lacrimal canaliculus laceration, irrigation needle tip indicating the lacrimal canaliculus nasal side cut end

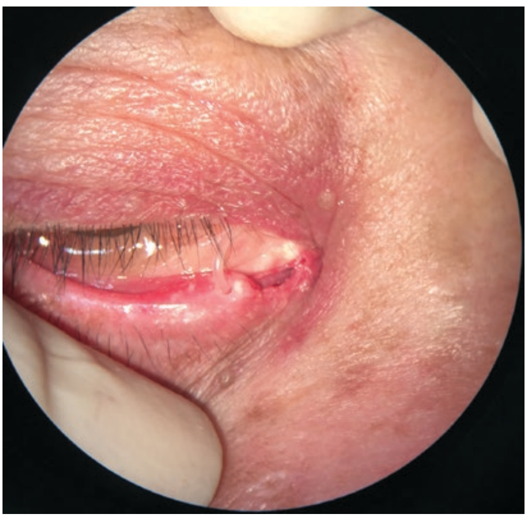

Fig. 9.7 Lacrimal canaliculus laceration, bicanalicular intubation with silicone tube stent

Fig. 9.8 Three days after anastomosis of lacrimal canaliculus in patients with laceration of lacrimal canaliculus

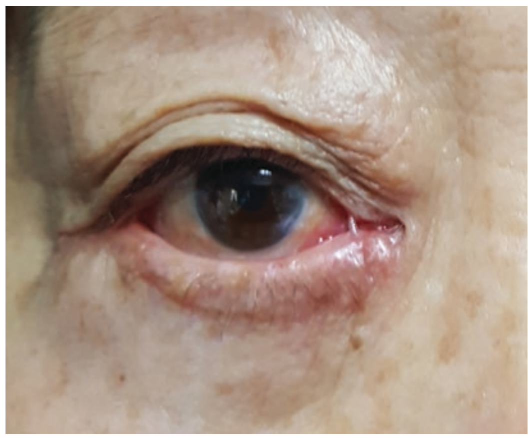

Fig. 9.9 Patients with laceration of the inferior lacrimal canaliculus underwent bicanalicular intubation and anastomosis 4 weeks later

9.4.2 Tips and Pearls

Laceration of lacrimal canaliculus can occur in any part of lacrimal canaliculus theoretically, and the laceration of inferior lacrimal canaliculus is the most common in clinic. The diagnostic basis of inferior lacrimal canaliculus laceration: (1) there is a definite history of injury; (2) serious cases can be seen if the medial side of the lower eyelid and medial canthus have lacerated wound and bleeding; (3) the temporal cut end of the lacrimal canaliculus can be detected by using lacrimal irrigation needle or lacrimal probe; and (4) ocular, orbital, and peripheral tissue injury may be combined.

Once the laceration of lacrimal canaliculus is confirmed, the repair surgery should be carried out as earlier as possible. In the case of nasal

bone injury, canaliculus anastomosis and repair of inner canthus and eyelid should be performed after nasal bone reduction. If necessary, ask an otolaryngologist for assistance. Regarding the timing of the operation, the current diagnosis and treatment norms are as follows: 1 week after the lacrimal canaliculus laceration, primary repair surgery is difficult to succeed, thus needing a reversion operation. New conception: the repair surgery as appropriate for up to 2 weeks in most of the patients.

The operation should clean the wound and remove contaminants. The wound can be rinsed with 2% hydrogen peroxide and then rinsed with normal saline. Conditions should be timely for an anastomosis canaliculus and suture eyelid canthus wound. It is difficult to find the cut end of the nasal canaliculus, the following are the useful methods: direct probing under a microscope; injecting colored solution or disinfecting milk into the upper lacrimal canaliculus, and using a pigtail probe, if necessary; making dacryocystotomy; and retrograde probing through the common canaliculus to detect. If the hospital conditions are limited and incompetent to repair, the patient should be referred to the superior hospital for surgery. If a doctor wants to transfer the patient to a distant hospital for treatment, he/she needs to simply suture the eyelid and canthus wound and then transfer.

Traditional lacrimal canaliculus repair method: epidural catheter was used as lacrimal stent [10], this epidural catheter exposed after surgery can affect the appearance of the patient, making it easy to be accidentally pulled out by the patient, and after surgery the epidural catheter might lead to erosion and eversion of the punctum. The sutures remain in the end-to-end anastomosis site, and the residual sutures can cause inflammatory granuloma, which can cause canalicular stenosis and obstruction. The improved method is monocanalicular intubation or bicanalicular intubation with silicone lacrimal stent instead of epidural catheter (Fig. 9.10), which generally requires at least 3 months, so as to avoid lacrimal anastomosis site scar stenosis. With regard to the improvement of lacrimal canaliculus anastomosis method, Tao Hai et al. (Fig. 9.11) reported that the lacerated lacrimal canaliculus was anastomosed by a method of "one stich through the skin." During the operation, bicanalicular intubation with silicone lacrimal stent was used as the inner support of lacrimal canaliculus. 5-0 silk suture was used to anastomose the upper wall or the front wall of the canaliculus through the skin for one stich, and the suture was removed for 7 days to obtain better therapeutic effect. The stent placement methods can be selected as Crawford's method, Ritleng's method, and "suture loop traction bicanalicular placement method," so-called Tao's method [11], etc.

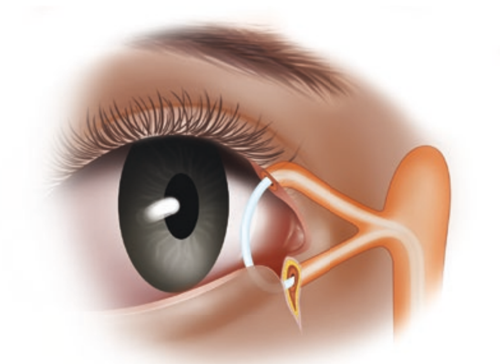

Fig. 9.10 Inferior canalicular laceration with bicanalicular silicone tube intubation [11]

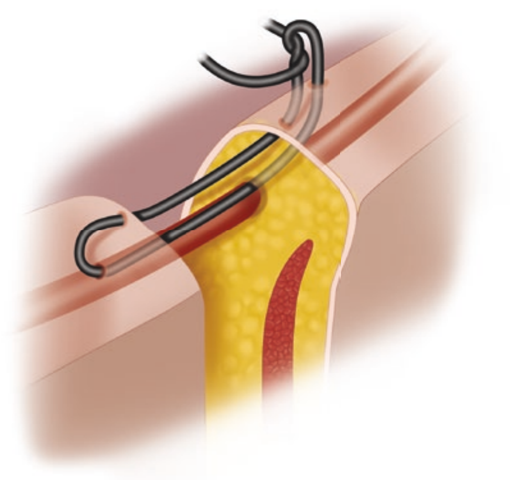

Fig. 9.11 Tao's one-stitch anastomosis through the skin to repair canalicular laceration [9]

Kersten and Kulwin [12] (Fig. 9.12) first reported the use of "one-stitch" method to repair

Fig. 9.12 Kersten's one-stitch repair of the canalicular laceration [12]

laceration of the lacrimal canaliculus. This method only sutures one stitch of connective tissue around the canaliculus, but not directly sutures the canaliculus wall. This method simplifies the operation, but the alignment of the two broken end walls is not necessarily accurate. There is still one suture end remained in the wound, of which might form suture granuloma, which might cause stenosis and obstruction of the canaliculus. Tao et al. [13] reported the use of "one-stitch anastomosis through skin" to repair canalicular lacerations, the main advantage of this procedure: with the anastomosis having a suture through the canalicular wall and lumen, the alignment of the two broken end walls is accurate, and the wound of the eyelid and the inner canthus can be simultaneously sewed, thereby simplifying the operation and saving time. 5/0 silk anastomosis is economical and suitable for patients with high tension of the wound. All sutures were removed after surgery; this avoids stenosis or obstruction of the canaliculus caused by inflammatory granuloma that is caused by residual sutures.

Tetanus antitoxin 1500u subcutaneous injection within 24 h or tetanus immunoglobulin 250iu intramuscular injection within 24 h. Patients with severe wound contamination can be treated by systemic antibiotics for 3–5 days after operation.

9.5 Case #4: Lacerations of Inferior and Superior Canaliculi with Serious Eyelid Lacerations Bitten by a Dog

9.5.1 Case Description

A 30-year-old woman was admitted to the hospital for epiphora and deformity of the eyelid and medial canthus after being bitten by a dog on the left eyelid and cheek 3 months ago. The patient's left eyelid and cheek were bitten by a dog 3 months before admission, feeling pain and discomfort, accompanied by bleeding. He was admitted to the hospital with "left upper and lower lacrimal canalicular laceration, left eyelid and cheek injury bitten by dog." Ophthalmic examination: left eye visual acuity was 6/10 (Snellen chart); eyelids and cheek skin showed extensive damage (Fig. 9.13), inner canthus angle deformation, partial loss of tissue, upper and lower lacrimal punctum position with the displacement of upper and lower eyelid. The upper and lower canaliculus probing through the punctum both indicated about 3 mm from the lacrimal punctum to the site of laceration. Anterior segment and fundus examinations were normal. Intraocular pressure: 14 mmHg (non-contact tonometer). The eyelid and cheek wound had been previously sutured in other hospital; due to limited conditions, the upper and lower lacrimal canaliculus could not be repaired, and local scar deformity was

Fig. 9.13 The upper and lower lacrimal canalicular laceration with extensive eyelid and cheek injury bitten by a dog

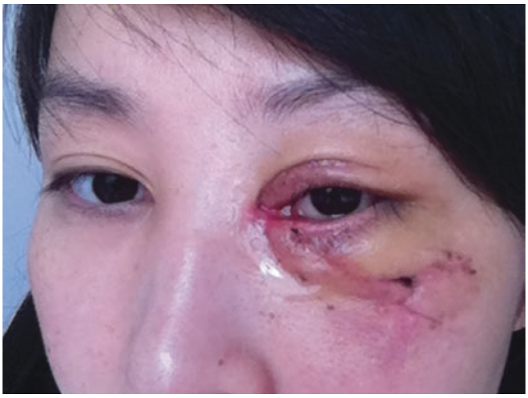

Fig. 9.14 Twelve days after initial eyelid and cheek repair surgery, failed anastomosis of lacerated lacrimal canaliculi, traumatic scar deformity is obvious

Fig. 9.16 The same patient 3 days after the second operation

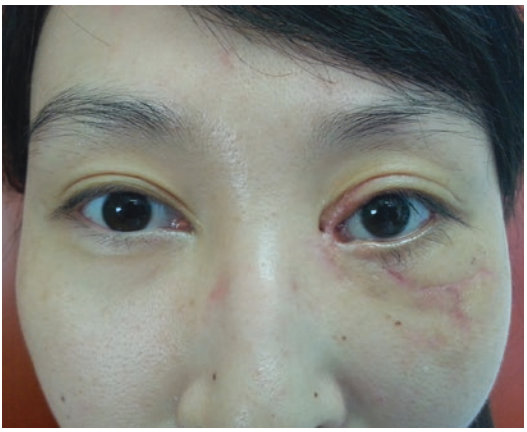

Fig. 9.15 Old upper and lower lacrimal canaliculus laceration with eyelid inner canthus traumatic deformity and lower eyelid eversion, before the second operation

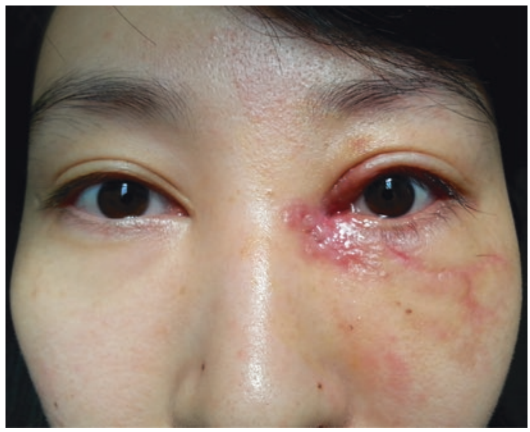

Fig. 9.17 The same patient 2 weeks after the second operation

obvious after injury (Fig. 9.14). After 3 months, the epiphora symptoms of the left eye were obvious. Ophthalmic examination: the upper and lower lacrimal canaliculus had a soft stop at 3 mm from the lacrimal punctum and could not be broken through with a probe. There were fistulas of the upper and lower lacrimal canaliculus to the skin and traumatic deformity of the inner canthus angle with lower eyelid eversion (Fig. 9.15); thus, the patient was admitted to the Lacrimal Apparatus Center of Armed Police General Hospital of China and was proposed to have lacrimal canaliculus repaired. Under local anesthesia, a small-incision dacryocystotomy was performed, through the common canaliculus, to detect the upper and lower lacrimal canaliculus cut end retrogradely; both lacerated canaliculi were repaired, and lacrimal canaliculus-skin fistula resection and bicanalicular intubation, lower eyelid correction, and inner canthoplasty have been done. The appearance of the patients was improved 3 days and 2 weeks after operation (Figs. 9.16 and 9.17). When discharged from hospital, the patient was generally in good condition, the skin incision in the left lacrimal sac region and the upper and lower lacrimal canaliculus incision were in good alignment, and the lacrimal stent was in place. After 1 year of follow-up, the tear symptoms disappeared, the upper and lower lacrimal canaliculus patency was restored, and the appearance recovered well (Fig. 9.18).

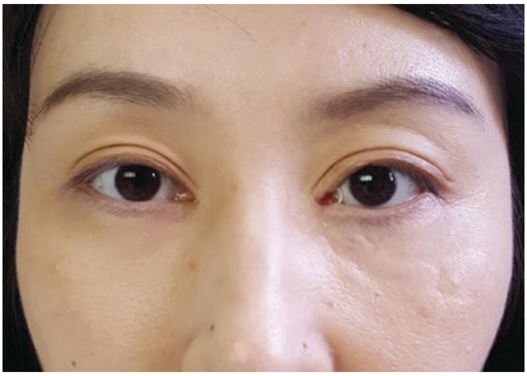

Fig. 9.18 The same patient 1 year after the second operation

9.5.2 Tips and Pearls

Although in lacerations of lacrimal canaliculus, both upper and lower canalicular laceration at the same time is not common in clinic, the repair is always difficult. The view in the past is that only the lower lacrimal canaliculus is to be repaired, thus often giving up the repair of the upper lacrimal canaliculus; but if this is the case, the patient after surgery would appear to have mild epiphora symptoms because the upper lacrimal canaliculus have not been repaired, so the present view is to repair the upper and lower lacrimal canaliculus as far as possible at the same time.

This patient was bitten by a dog, and the injury is serious. In recent years, the number of patients bitten by dog has increased gradually, so we need to be alert. Different from common eyelid laceration with canalicular laceration, special treatment of dog bite should be considered.

Wounds bitten by dogs are usually open because they are known for infection, if initially closed. A prospective randomized trial was conducted to compare primary closure with keeping the wound open to assess infection and cosmesis. 96 patients with 169 lacerations underwent thorough debridement and wound irrigation. 92 wounds were sutured and 77 were not sutured. No prophylactic antibiotics were used. There were 13 wound infections: 7 were sutured and 6 were not sutured (no statistically significance); the total infection rate was 7.7%. The conclusion was that dog-bite wounds should receive thorough surgical treatment and can be safely sutured when they occur [14].

To care for dog-bite wound: to stop any bleeding, carefully clean the wound with soap and water, and then check whether the wound is deep enough to damage muscles, tendons, nerves, or bones. Then thoroughly clean the bite, remove any dirt or bacteria, and also remove dead tissue from the wound. Sometimes sutures are used to suture wounds bitten by the dogs. Although suturing wounds can reduce scars, it also increases the risk of infection. Whether the injury is closed or not depends on its position. For example, wounds that dogs bite on the faces should be sutured to prevent visible scars. Very deep wounds that cause huge injuries may require plastic surgery.

Rabies vaccine, tetanus antitoxin, or tetanus human immunoglobulin injection shall be administered within 24 h. Patients with severe wound contamination can be treated by systemic antibiotics for 3–5 days after operation.

In surgical treatment of patients with simultaneous laceration of upper and lower lacrimal canaliculus, Tao et al. [13] reported “one-stich anastomosis through skin with bicanalicular intubation” as a support through the insertion of a silicone tube stent into the lacrimal canaliculus (Fig. 9.19). If the wound tension is low, 8-0 suture could be used direct anastomosis; if the wound is under greater tension, 5-0 silk suture should be used; the specific anastomosis method

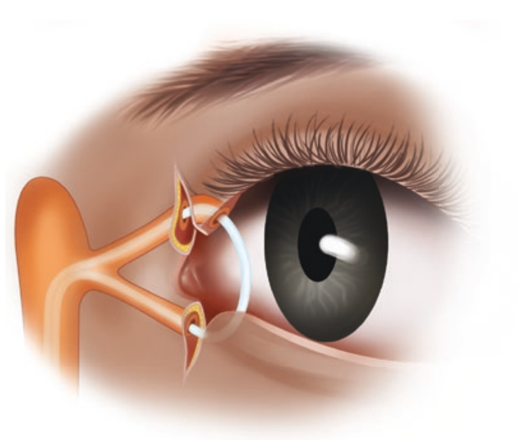

Fig. 9.19 Both upper and lower canalicular laceration in one eye with bicanalicular silicone tube intubation [11]

is the same in Case 3. In the postoperative regular review, observe the lacrimal stent, lacrimal punctum with or without expansion and with or without abnormal eyelid position, and lacrimal punctum eversion. Remove the stent 6 months after second operation when the lacrimal duct irrigation is unobstructed. The main advantages of this method are that it can anastomose both lacerated upper and lower lacrimal canaliculus at the same time and it is safe and effective.

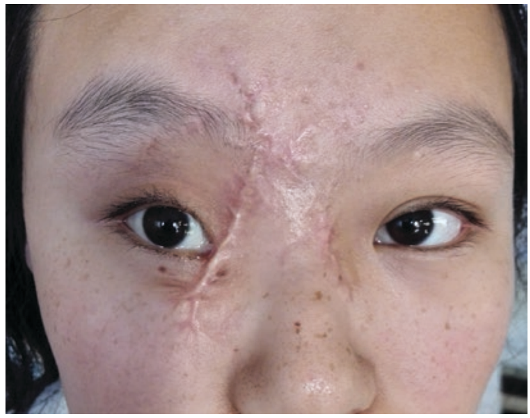

Fig. 9.20 Old laceration of the upper and lower lacrimal canaliculi in the right eye with traumatic eyelid and canthus deformity before operation

9.6 Case #5: Old Lacerations of Inferior and Superior Canaliculi Combined with Medial Canthus Deformity

9.6.1 Case Description

A 14-year-old girl was admitted to the Lacrimal Apparatus Center of Armed Police General Hospital of China for epiphora and deformity of the eyelid and inner canthus after being injured in a traffic accident 4 months ago. Four months ago, the upper and lower eyelids and inner canthus of the right eye were collided and injured in a traffic accident. A doctor in the local hospital examined and diagnosed the upper and lower lacrimal canaliculus laceration. Due to limited conditions, only the wound of the inner canthus and eyelids were debrided and sutured, and the lacerated lacrimal canaliculi were failed to be repaired because the cut ends could not be found. Ophthalmic examination: right eye visual acuity 6/10 (Snellen chart), normal intraocular pressure, medial canthus angle downward displacement of 3 mm, lateral displacement of 2 mm, medial canthus were deformity with proliferative scar (Fig. 9.20), eyelid closure was not complete, eye movement was as usual, and no swelling and pain. Irrigation of lacrimal passage: probing the upper canaliculus, there was a soft stop 2 mm far from the upper punctum, and the probe could not break through. Anterior segment and fundus examinations were normal. The intraocular pressure was 16.7 mmHg. The diagnosis: old laceration of the upper and lower lacrimal canaliculus in the right eye, traumatic medial canthus and eyelids deformity of the right eye, and incomplete closure of palpebral fissure after trauma of the right eye. After admission, the reversion surgery has been performed, in which the "Z" incision was made, the lacerated upper and lower lacrimal canaliculi were repaired, and there was a complete eyelid and canthus deformity correction with the pedicled flap transposition (Fig. 9.21) at the same time. The upper and lower lacrimal canaliculi were repaired with a small incision of the lacrimal sac, and to detect the cut ends with retrograde probing through the common lacrimal canaliculus under local anesthesia, the upper eye-

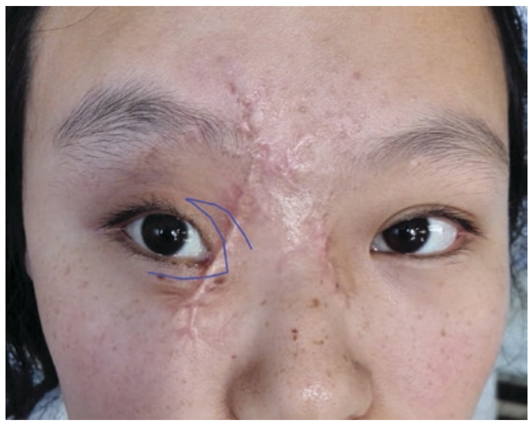

Fig. 9.21 "Z" incision was planned to be made for the surgery of repairing the lacerated lacrimal canaliculi and treating the eyelids and inner canthus deformity

lid pedicled flap was transferred to the lower eyelid for the blepharoplasty and canthoplasty. The right inner canthus deformity was corrected, and the lower eyelid skin incision was well aligned after surgery (Figs. 9.22, 9.23, 9.24, and 9.25). Six months after operation, the upper and lower lacrimal canaliculi were unobstructed, the appearance was improved significantly (Fig. 9.25), and no recurrence was found after 1 year of follow-up.

9.6.2 Tips and Pearls

Some patients with laceration of lacrimal canaliculus were defined as having old laceration of lacrimal canaliculus because they failed to undergo initial repair in time due to the limitation of primary hospital conditions or failed to undergo initial repair. The repair of old lacrimal canalicular laceration is called the second-stage repair of lacrimal canalicular laceration. Compared with the initial repair of fresh laceration of lacrimal canaliculus, the curative effect is relatively poor. The basis for diagnosis of old laceration of lacrimal canaliculus: (1) Clear history of injury, (2) Eyelid and medial canthus wound healing after laceration, local traumatic scar, some patients with punctum have shift, (3) irrigation lacrimal duct, in traumatic scar blocking, most patients's irrigation fluid back flow, and some patients irrigation fluid from the old wound fistula overflow, (4) Probing can be found that the temporal side of the lacrimal canaliculus cut end, a few can be found medial cut end.

Fig. 9.22 Same patient 3 days after surgery

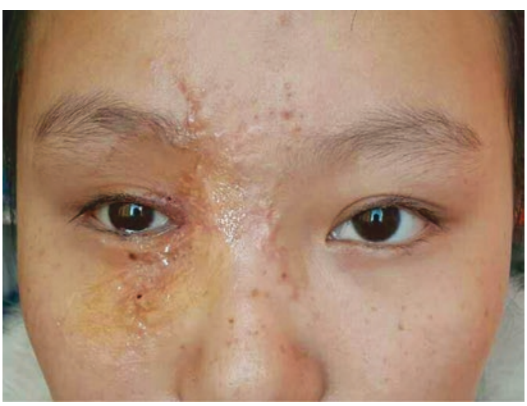

Fig. 9.23 Same patient 2 weeks after surgery

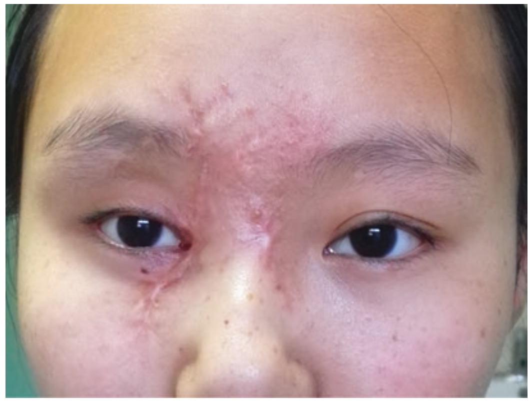

Fig. 9.24 Same patient 3 months after surgery

Fig. 9.25 Same patient 6 months after surgery

Principles and key points of management of old laceration of the canaliculus are following.

(1) Careful preoperative examination and evaluation of the location, extent, and end of the lacerated canaliculus. Some cases of old lacerations of the canaliculus can be examined with UBM to detect the cut end of the canaliculus [15]. For the patient of old laceration of both upper and lower lacrimal canaliculus, that could not to be injected the contrast into the lacrimal duct through the punctum, may undergo the CT retrograde intubation dacryosystography to determine the lacrimal sac, nasolacrimal duct and canaliculus medial segment [16]. The methods to detect the medial cut end of lacrimal canaliculus during operation include the following: (1) cut the original wound and find it directly, (2) use a pigtail probe rotated through a healthy canaliculus to probe the cut end of the lacerated canaliculus, and (3) perform the small-incision dacryocystotomy, with retrograde probing through the common canaliculus to probe the cut ends of the lacrimal canaliculi. Lacrimal canaliculus repair and blepharoplasty and canthoplasty should be performed at the same time to achieve anatomical reduction and deformity correction as far as possible.

For the prevention and treatment of postoperative infection, remove the sutures 7 days after surgery. Regularly review the stent retention for more than 3–6 months. When the check shows there are no canaliculus stenosis, the stent might be removed. The success rate of repairing the old lacerated canaliculus is lower than that of initial surgery. To the patient whose both cut ends of upper and lower lacrimal canaliculi were difficult to be found in operation, 7 mm arc incision might be made through skin in the front wall of lacrimal sac, dacryocystotomy, and the cut end of upper and lower lacrimal canaliculi.

9.7 Case #6: Lacrimal Sac and Nasolacrimal Duct Injury

9.7.1 Case Description

A 2-year-old boy was admitted to the hospital for 3 days after his right eye and face were accidentally hit by a radiator. Three days ago before he come to the Armed Police General Hospital, an unexpected injury to his right side of the face near the inner canthus leaded the skin full-thickness laceration that hit by a radiator. Facial skin laceration was initially sutured and the fracture nasal bone reduction in the local hospital emergency room; when the injury was stable, the patient was transferred to the Lacrimal Apparatus Center of Armed Police General Hospital of China for further treatment. Ophthalmic examination: right eye visual acuity was not examined for the child did not cooperate, a skin laceration of about 90 mm in length from the middle of the forehead 30 mm above the horizontal line of the eyebrows has been sutured and the placed epidural catheter as a lacrimal stent exposed (Fig. 9.26), the eyelid slightly red and swollen, eyeball position and movement as usual, upper and lower punctum shape is narrow, and epidural catheter in place, one end of the catheter was in the lower lacrimal canaliculus, and one end fixed to the skin. Conjunctival congestion and intraocular pressure: Tn. Anterior segment and fundus examinations were normal. CT showed a fracture of the bony nasolacrimal duct and lacrimal fossa and the right medial orbital wall (Figs. 9.27, 9.28, and 9.29). Diagnosis: lacrimal sac rupture of the right eye, fracture of the bony nasolacrimal duct and lacrimal fossa and the right medial orbital wall, right facial skin lacera-

Fig. 9.26 Patient having right lacrimal sac rupture with fracture of lacrimal sac fossa and nasolacrimal duct, about 90 mm long arc skin laceration, has been initial sutured, placed epidural catheter as a lacrimal stent exposed

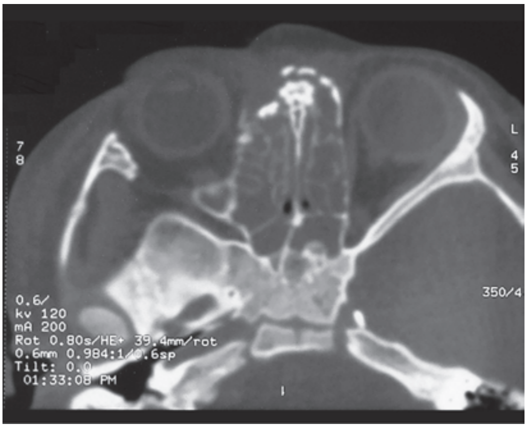

Fig. 9.27 CT horizontal position of lacrimal fossa and bony nasolacrimal duct fracture in the right orbital medial wall

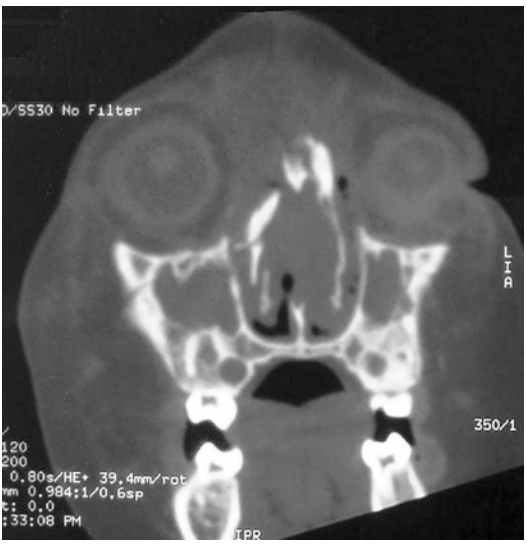

Fig. 9.28 CT coronal position showed the fracture of right orbital medial wall of the lacrimal sac fossa and bony nasolacrimal duct

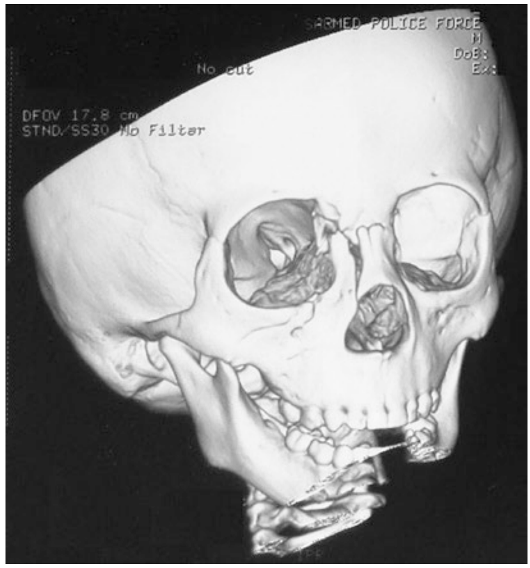

Fig. 9.29 CT three-dimensional reconstruction showed there were fractures in lacrimal fossa and bony nasolacrimal duct in the medial wall of the right orbital

Fig. 9.30 A larger wound, about 90 mm long, deep into the orbit 35 mm

tion, inferior lacrimal canaliculus epidural catheter placement of the right eye, and right nasal bone fracture. An emergency surgery was performed under general anesthesia: ruptured lacrimal sac suturation, bicanalicular intubation, and skin laceration. Remove the initial sutures and carefully probe and clean the wound, and see if the wound is large (Fig. 9.30), about 90 mm long, deep into the orbit of 35 mm. Under the operation microscope, the fracture of the bony nasolacrimal duct and lacrimal sac fossa on the orbital medial wall was seen (Fig. 9.31). During the operation, bicanalicular silicone stent combined with nasolacrimal duct silicone stent was intubated (Fig. 9.32). At the end of the operation, the wound was well aligned, and the lacrimal stent was not exposed after the bicanalicular intubation (Fig. 9.33). Anti-inflammatory therapy was given after surgery, and the patient recov-

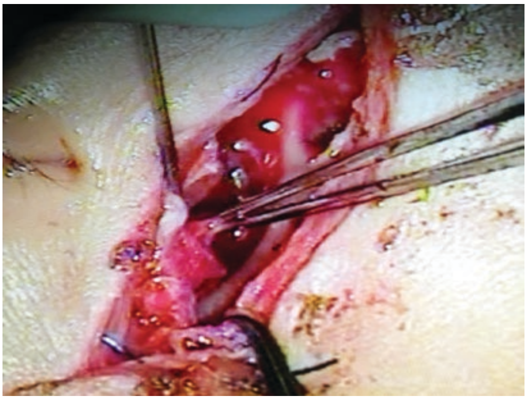

Fig. 9.31 The rupture of right lacrimal sac and fracture of lacrimal fossa

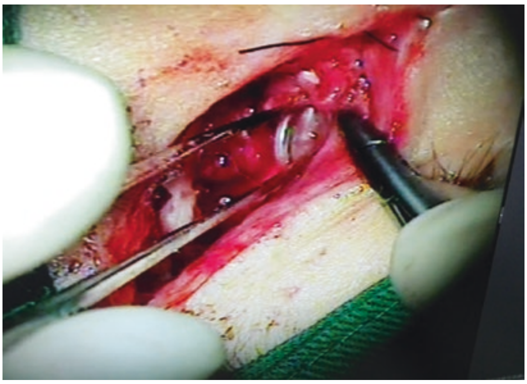

Fig. 9.32 Bicanalicular silicone stent combined with nasolacrimal duct silicone stent was intubated in operation

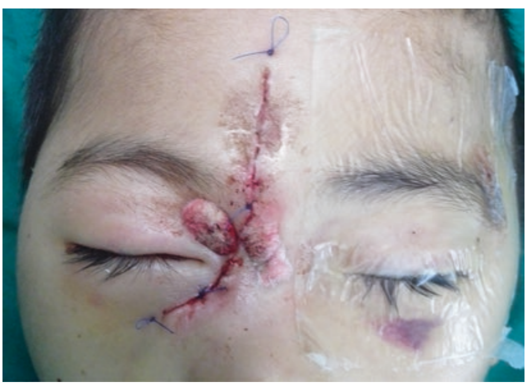

Fig. 9.33 Right lacrimal sac rupture and bony nasolacrimal duct fracture of patient after second surgery

ered well after operation. Check at discharge: right facial skin laceration is in good alignment, and suture and lacrimal stent is in place.

Fig. 9.34 Same patient 6 months after surgery

Fig. 9.35 Same patient 2 years after surgery

After 6 months of follow-up, the symptoms of epiphora disappeared, lacrimal duct irrigation unobstructed, and a good appearance recovery (Fig. 9.34), and no recurrence was found after 2 years of follow-up (Fig. 9.35).

9.7.2 Tips and Pearls

Injuries of midface region involving fracture of maxillofacial and nasoethmoidal region are becoming more and more common nowadays. It may lead to lacrimal sac and/or nasolacrimal duct (NLD) impaired. These types of injuries occur most often after blunt blow, such as traffic accidents and violent injury. A detailed ophthalmic examination is essential for any patient presenting with midface trauma; it is important

to carefully examine the lacrimal system. Any injury in this area puts the patient at high risk for lacrimal system injury, and it is necessary to rule out eyeball trauma prior to further manipulation, especially orbital fracture.

Computed tomography (CT) is ideal in the trauma evaluating the lacrimal fossa and lacrimal nasolacrimal duct injury. It also allows evaluation of surrounding tissues in trauma or anatomic variants that may complicate planned surgery. When combined with injected contrast, the technique of three-dimensional CT reconstruction is excellent at identifying bony structures around the nasolacrimal system. Using this technique, the surgeon can identify accurately obstructions in the nasolacrimal system and evaluate the size of the lacrimal sac.

Primary repair of a lacrimal sac rupture can be considered depending on the type of rupture and related injuries. If the injuries are contiguous with the medial canthal injury, repair of the sac with direct closure and bicanalicular silicone intubation is reasonable.

If the lacrimal sac is damaged seriously and is too small to anastomose, lacrimal sac reconstruction can be performed with a patch conjunctival or nasal mucosa served as a free graft. In some special case of patients, the ethmoid mucosa also may be used for lacrimal sac reconstruction.

If the patient has symptomatic tearing, bicanalicular silicone stent intubation can be performed concomitantly with repair of associated midfacial fractures. Similar to canalicular and lacrimal sac lacerations, but not similar to the normal bicanalicular silicone stent intubation which is applied to the canalicular laceration, this bicanalicular silicone stent combined with nasolacrimal duct silicone stent should be intubated (Fig. 9.36) which acts as a temporary stent during the healing process of the damaged NLD and damaged lacrimal sac. The patient was managed with corticosteroid and antibiotic eye drops for several weeks following surgery to prevent bacterial infection. The stents can be removed 12–24 weeks after repair.

For patients who do not receive primary repair in the first week after the injury, or who suffered traumatic dacryocystitis, it is generally acceptable to perform a dacryocystorhinostomy (DCR) later if needed. The method of "modified technique of external dacryocystorhinostomy" might be used for the purpose of simplifying the operation and prevention of flap sag and the internal ostium obstruction or the posterior flap anastomosis scarring. Many studies suggest that external DCR by suturing anterior and posterior flaps has no advantage over dacryocystorhinostomy by suturing only anterior flaps [17–19].

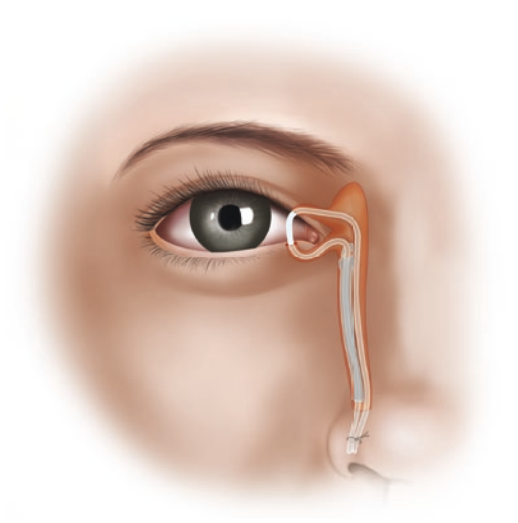

Fig. 9.36 Bicanalicular silicone stent combined with nasolacrimal duct silicone stent was intubated

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10 Orbital Injury

Yueyue Li, Hai Tao, and Xibin Zhou

Abstract

Orbital injury includes orbital soft tissue contusion, orbital fracture, orbital foreign bodies, etc. This chapter mainly discusses the injury of soft tissue and the orbital wall behind the orbital septum. The early reactions of orbital trauma were hemorrhage, exudation, and edema, and the late pathological changes were scar adhesion and fat atrophy. Mild orbital injury, such as orbital soft tissue contusion, generally does not need surgical treatment, but more serious orbital injury, such as orbital fracture which causes obvious eye sag, strabismus, etc., needs surgical treatment. This chapter report includes six cases of orbital injury, to provide a guide about diagnosis and management of orbital injury.

Keywords

Orbital injury · Orbital contusion · Orbital fracture · Foreign body

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10.1 Introduction

Orbital trauma includes orbital soft tissue injury, orbital fracture, orbital foreign body, etc. This chapter mainly discusses the injury of the soft tissue and orbital wall behind the orbital septum. The content about the eyeball, optic nerve, extraocular muscle, and lacrimal apparatus trauma can be seen in other chapters. There are three main characteristics of orbital injury: first, because of the deep tissue and the influence of the eyeball, it often could not be seen directly; second, because orbital margin is thick and orbital wall is thin, bone orbital wall fracture occurs in orbital wall rather than orbital margin, so most orbital fracture could not be reached; third, because the orbital and paranasal sinuses are adjacent, it often presents a complex injury. The early reactions of orbital trauma were hemorrhage, exudation and edema, which reached the peak within a few hours to 3 days after injury. With the improvement of blood circulation, hemorrhage and edema were gradually absorbed. Late pathological changes were scar adhesion and fat atrophy, generally from 2 weeks after injury to 3 months being stable. Mild orbital injury, such as orbital soft tissue contusion, generally does not need surgical treatment, but more serious orbital injury, such as orbital fracture causing obvious enophthalmos, strabismus, etc., needs surgical treatment.

H. Yan (ed.), *Atlas of Ocular Trauma*, Ocular Trauma, https://doi.org/10.1007/978-981-13-1450-6_10

10.2 Case #1: Orbital Soft Tissue Contusion with Emphysema of the Orbit and Eyelid

10.2.1 Case Description

A 25-year-old woman was referred to the Department of Orbital Diseases of the Armed Police General Hospital of China, for redness, swelling, and pain in the upper eyelid after eye boxing injury for 3 days. Three days ago, the patient was boxing injured on the left eye, the skin of the eyelid became swollen and mild red, and she had mild difficulty in opening the eye (Fig. 10.1). Diagnosis: Orbital soft tissue contusion with emphysema of the orbit and eyelid in the left eye. Physical examination: Visual acuity 8/10 (Snellen chart), mild redness in the left upper eyelid skin, subcutaneous emphysema, swelling, mild ptosis covering 1/2 pupil, normal eye position, normal eye movement in all directions. Exophthalmos: 15 mm in the right eye, 13 mm in the left eye, and 110 mm in the orbital distance. Slit-lamp microscopy: conjunctiva congestion, corneal transparency, normal anterior chamber, KP (−), Tyndall's sign (−), normal iris color, pupil size about 3 mm in diameter with normal reflection of light. The fundus was normal, and intraocular pressure was normal. CT showed irregular low-density areas (horizontal position) beneath the upper eyelid and above and inside the orbit (Figs. 10.2 and 10.3). Without special treatment, soft tissue edema and emphysema subsided after 2 weeks. Follow-up for 3 months showed the left eye ptosis recovered well, with slight enophthalmos.

Fig. 10.1 Orbital soft tissue contusion with emphysema of the orbit and eyelid in the left eye

10.2.2 Tips and Pearls

Orbital soft tissue contusion is common in clinic. Blunt object striking or collision can lead to orbital soft tissue contusion, such as eyelid and periorbital edema, subcutaneous congestion, and bluish purple, and may be accompanied by ptosis; the eyeball movement is restricted with emphysema of the orbit and eyelid.

Eyelid subcutaneous and orbital emphysema mostly occurred after ocular trauma, orbital wall fracture caused by narrow gap between orbit and

Fig. 10.2 CT showed irregular low-density areas (horizontal position) beneath the upper eyelid and above and inside the orbit in left eye, diagnosis: orbital soft tissue contusion with emphysema of the orbit and eyelid

Fig. 10.3 CT showed irregular low-density area (coronal position) beneath the upper eyelid and above and inside the orbit in the left eye

paranasal sinuses, such as blowing the nose after injury which can cause gas into the orbit or subcutaneous emphysema through the gap. More emphysema can cause exophthalmos [1]. On CT, the gas shows the same low density as the sinus density; the boundary is clear and neat and can be located in the eyelid or orbit. The density of it in the orbit is similar to that in the retrobulbar fat. Because of the strong acoustic resistance of the gas, ultrasound is difficult to pass through the gas which appears as acoustic shadow and has ultrasonic characteristics similar to foreign bodies.

In most cases, orbital soft tissue contusion needs no special treatment, for 1–2 weeks, the soft tissue edema and hematoma subsided, and emphysema generally also subsided. Serious soft tissue contusion of tissue edema and bleeding recovery is slow. If emphysema makes orbital pressure significantly increased, syringe puncture in the site, to suck out the air. Orbital soft tissue contusion may be accompanied by eyelid and periorbital skin laceration, which requires emergency debridement and suturing. If secondary bacterial infections occur, antibiotic therapy is required. If the orbital hemorrhage is serious, exophthalmos is obvious, and orbital pressure is extremely high and endangers vision, it is necessary for timely orbital decompression surgery. As long as the treatment is timely, most patients have a good prognosis.

Fig. 10.4 The left eye upper eyelid groove deepened, the upper eyelid lifts in place, and the eyeball invaginates

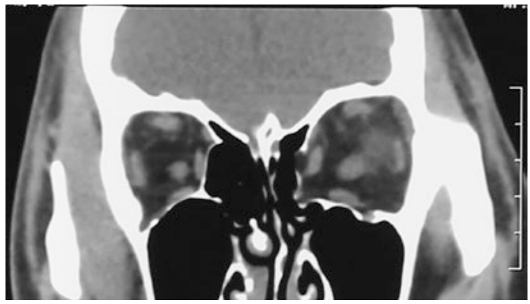

Fig. 10.5 Orbital coronal CT showed that the left medial orbital wall was depressed by fracture, the corner was slightly displaced, and the medial rectus muscle and a small amount of adipose tissue were herniated into the ethmoid sinus

10.3 Case #2: Orbital Medial Wall Fracture with Enophthalmos

10.3.1 Case Description

A 22-year-old man was admitted to the hospital for 1 year after his left eye was injured by someone else's elbow during exercise. One year ago, he was injured; his eyes were painful and swollen. CT scan showed that the left orbital medial wall was fractured, no treatment was received, and the left eye was gradually sunken. The patient's aim was to improve the appearance of the left eye. Examination: left eye, visual acuity 0.8, eyelid swelling, upper eyelid groove deepening, lifting in place of the upper eyelid, positive eye position, and eyeball invagination (Fig. 10.4). Measurement of exophthalmos: 15 mm in the right eye, 13 mm in the left eye, and orbital distance of 110 mm. The movement of the eyeball was restricted slightly in the upward and downward rotation and was normal in other directions, the conjunctiva was not congested, the cornea was transparent, and intraocular pressure and orbital pressure were normal. Coronal CT of the orbit revealed compression fracture of the medial orbital wall, slight displacement of the corner, hernia of the medial rectus muscle, and a small amount of adipose tissue into the ethmoid sinus (Fig. 10.5). Diagnosis: old fracture of the medial orbital wall with enophthalmos in the left eye. Under general anesthesia, the left orbital fracture was repaired by inserting a piece of artificial bone into the orbit from the conjunctival incision near the medial lacrimal fossa,

Fig. 10.6 Six days after operation, the left eyelid was slightly swollen, the upper eyelid was slightly drooping, the eye position was normal, and the correction of left enophthalmos was satisfactory

Fig. 10.7 Six days after operation, the left eyelid was slightly swollen, the upper eyelid was slightly drooping, and the left eyeball rightward rotation was normal

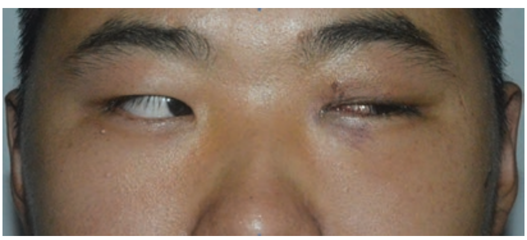

Fig. 10.8 Six days after operation, the left eyelid was slightly swollen, the correction of left enophthalmos was satisfactory, and the leftward rotation was normal

the size of which was 3 × 3 cm, and the position of the artificial bone was adjusted to fully cover the fracture area. Six days after operation, the patient's left eye visual acuity was 0.8, the eye position was normal, the correction of eye depression was satisfactory, the eye rotation was good in every direction (Figs. 10.6, 10.7, and 10.8), the eyelid was slightly bruised, conjunctival congestion was slight, conjunctival incision was well aligned, and orbital pressure was normal. Postoperative coronal CT showed that the medial side of the left orbit was well positioned with curved artificial bone slices. The left medial orbital wall was reconstructed well, and the orbital cavity was restored (Fig. 10.9).

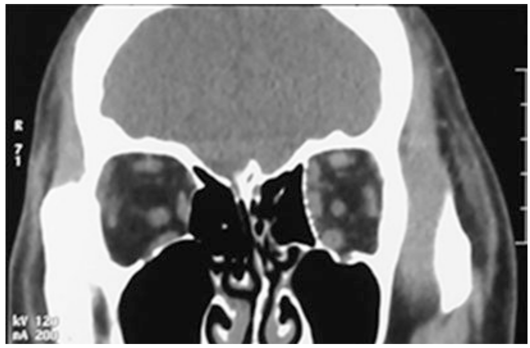

Fig. 10.9 Postoperative coronal CT showed that the medial side of the left orbit was well positioned with curved artificial bone slices. The left medial orbital wall was reconstructed well, and the orbital cavity was restored

10.3.2 Tips and Pearls

Orbital fracture is common in orbital trauma. Severe head-face injury by collision, eye boxing injury, falling injury, and traffic accident can lead to orbital fracture. Orbital fractures can be divided into blowout fracture and complex fracture according to injury condition and location. Blowout fracture is the most common orbital fracture. Fronto-orbital fracture, orbital zygomatic fracture, nasal-orbital-ethmoidal fracture, and other multiple fractures are collectively referred to as complex fractures.

Blowout fracture [2] is a kind of fracture caused by the indirect effect of external force and characterized by external force caused by orbital medial wall and orbital floor fracture, but the orbital margin is normal. It is generally believed that the object larger than 5 cm in diameter or greater than the diameter of the bony orbital rim is prone to cause such fractures such as boxing, wrestling, etc. The clinical manifestations of orbital blowout fracture vary with the pathological process of trauma, which can be divided into two stages: early and late; it becomes early within 3 weeks after trauma and late after 3 weeks. The early appearance of orbital blowout fracture was

blepharospasm, swelling, and exophthalmos. Typical symptoms of enophthalmos and diplopia occur after the swelling subsides. The larger the fracture range, the main occurrence of enophthalmos, the smaller the fracture range, the main cause of diplopia. The medial wall fracture often leads to the limitation of temporal direction rotation, and orbital floor fracture often appears the obstacle of upper and lower rotation of the eyeball; especially in children orbital floor fracture, it is more likely to cause inferior rectus muscle incarceration.

Orbital blowout fracture (OBF) accounted for about 7.5% of all ocular trauma and 47.3% of ocular trauma complicated with ocular adnexal injury or OBF. OBF was found in nearly 50% of craniofacial injuries. The incidence of OBF is increasing year by year with the increase of traffic accidents and sports injuries in recent years, and the incidence among young people is high. On the other hand, the patients' expectations for surgical correction of enophthalmos and improvement of ocular motor function are increasing [3].

Orbital medial wall fracture is the most common type of orbital fracture and often causes enophthalmos, with CT scan which can be clearly diagnosed [4]. During surgery, care should be taken to avoid injury of the optic nerve. Because the orbital wall is continuous at the orbital apex and the inner edge of optic canal and the optic nerve inclines inward into optic canal, it is easy to damage optic nerve if the operation is too deep or improper. Therefore, during the operation, the separation depth of the inner wall should not exceed 4.5 cm behind the medial orbital rim, avoid forcibly compressing soft tissue of the orbit, and prohibit the use of monopolar or bipolar electrocoagulation. Preoperative CT should be carefully observed, if the optic nerve with soft tissue displacement to the ethmoid sinus, in the middle of the orbit, may be at risk of optic nerve injury [5].

The posterior ethmoidal foramen was only 5–6 mm away from the inner edge of the optic canal and should be used as an anatomical marker to terminate deep dissection. Even if there are still some muscles or soft tissue is not completely separated from the fracture area, also don't force to seperate them. There are two reasons: (1) The risk of optic nerve injury is very high, and (2) this separation of isolated tissue on the eye movement function and eye depression correction effect is very small.

10.4 Case #3: Orbital Inferior Wall Fracture with Enophthalmos

10.4.1 Case Description

A 29-year-old man was admitted to the hospital for blurred vision and double vision in the right eye after boxing injury. Nine days ago, he got boxing injury in the right eye, redness, swelling, and pain. When he came to our department, the redness, swelling, and pain are obviously relieved, but enophthalmos presented, and double vision still remained. Physical examination: right eye, visual acuity 0.7, upper eyelid mild swelling, slight upward displacement of the eyeball, enophthalmos (Fig. 10.10) and subconjunctival hemorrhage. Measurement of exophthalmos: 13 mm in the right eye, 15 mm in the left eye, and orbital distance 105 mm. Corneal transparency, orbital pressure was normal. Medial and lateral rotation of the right eye was normal (Fig. 10.11), superior and inferior rotation of the right eye is not in place, and there is subconjunctival hem-

Fig. 10.10 A preoperative appearance: right eye upper eyelid light swollen, eyeball slightly shift, enophthalmos

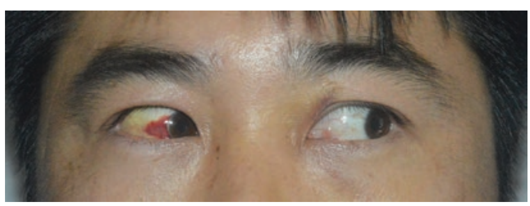

Fig. 10.11 Preoperative appearance: the right eye leftward rotated was normal

orrhage (Figs. 10.12, 10.13, and 10.14). Orbital CT horizontal position shows fracture of the right infraorbital wall and bone collapse of the right infraorbital floor (Fig. 10.15), and coronal position shows fracture of the right infraorbital wall, hernia of the inferior rectus muscle and intraorbital adipose tissue into the maxillary sinus, and slight thickening and displacement of the inferior rectus muscle, located in the fracture area (Fig. 10.16). Diagnosis: right infraorbital wall fracture with enophthalmos. The right orbital fracture was repaired under general anesthesia. During the operation, the inferior rectus muscle and the surrounding adipose tissue were restored into the orbital by the incision of the inferior fornix conjunctiva. Gradually exposing the edges of the fracture area, the absorbable artificial orbital floor was personalized cut, about 3.0 cm × 2.5 cm, and put to the infraorbital wall, the absorbable orbital floor position was adjusted, and the fracture area was completely covered, and whether enophthalmos correction was satisfactory was being observed and bilateral eyeball protrusion is nearly symmetrical, closed conjunctiva incision with 6-0 absorbable suture. Six days after operation, the right eye was slightly displaced upward, the downward rotation was slightly restricted, other movements were normal (Figs. 10.16, 10.17, 10.18, 10.19, 10.20, 10.21, and 10.22), and orbital pressure was normal.

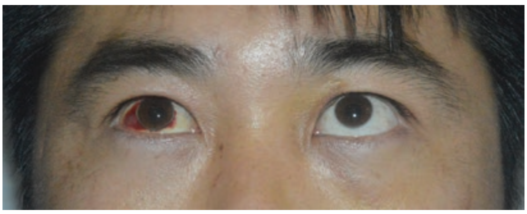

Fig. 10.12 Upward rotation of the right eye was restricted, subconjunctival hemorrhage

Fig. 10.13 Downward rotation of the right eye was restricted, subconjunctival hemorrhage

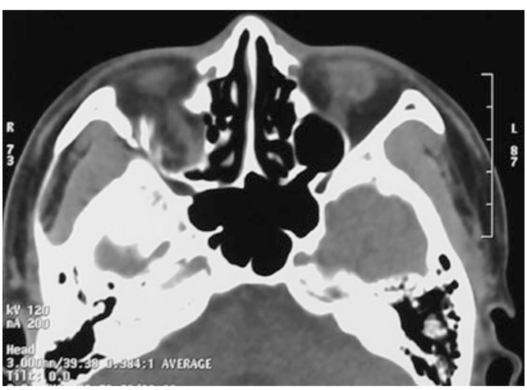

Fig. 10.14 Preoperative horizontal orbital CT showed that the right infraorbital wall was fractured and the right orbital floor bone collapsed

Fig. 10.15 Preoperative coronal orbital CT showed the right infraorbital wall fracture and the inferior rectus muscle and orbital adipose tissue hernia into the maxillary sinus

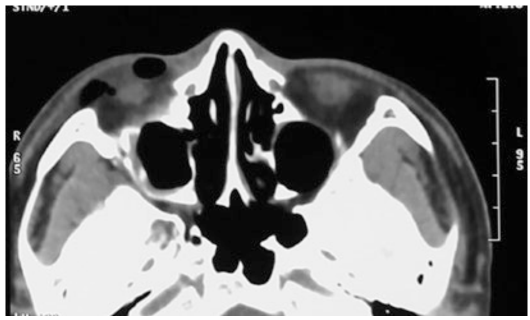

Fig. 10.16 Postoperative horizontal orbital CT showed that orbital floor shape recovered and local emphysema (low-density area) occurred after fracture of the right infraorbital wall

Fig. 10.17 Postoperative coronal CT showed that the material of absorbable orbital floor was put to the lower wall of the right eye in good position, the orbit returned to normal structure, and the inferior rectus muscle was restored in orbit

Fig. 10.18 Right infraorbital wall fracture appearance 6 days after operation, swelling of the right eyelid, and slightly upward displacement of the right eye

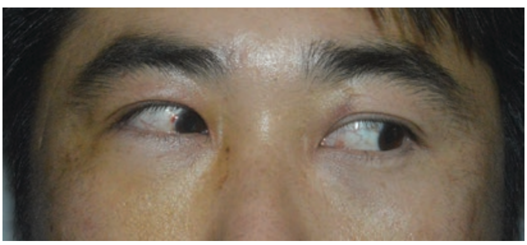

Fig. 10.19 Six days after operation, the right lower orbital wall fracture showed a swollen right eyelid, and the right eyeball leftward rotated was normal

Fig. 10.20 Six days after operation, the right lower orbital wall fracture showed a swollen right eyelid, and the right eyeball rightward rotated was normal

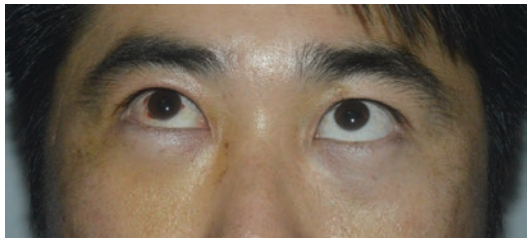

Fig. 10.21 Six days after operation, the right lower orbital wall fracture showed a swollen right eyelid, and the right eyeball upward rotated was normal

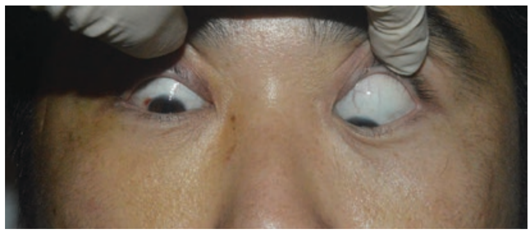

Fig. 10.22 Six days after operation, the right lower orbital wall fracture showed a swollen right eyelid, and downward rotation of the right eye was restricted

10.4.2 Tips and Pearls

Infraorbital wall fractures are more common in clinical practice, because of the infraorbital nerve through the infraorbital wall, so patients often have the infraorbital nerve innervation area numbness after surgery and can recover generally in 3–6 months. Intraoperative need to avoid injury the infraorbital nerve, so artificial materials should be located in the subperiosteal space, above the infraorbital nerve. During the operation, the four boundaries of the exposed fracture should be separated as far as possible, and the material should be placed to cover the fracture area, so as to avoid the material trailing edge being embedded into the deep part of the inferior rectus muscle. After placing the material, the inferior rectus muscle should be pulled to make sure that there is no resistance to the inferior rectus muscle, so as to ensure that the material is placed in the ideal position [6].

10.5 Case #4: Orbital Medial Wall and Inferior Wall Fracture with Enophthalmos

10.5.1 Case Description

A 26-year-old man was injured in his left eye by someone else's elbow during exercise 3 months ago. After the injury, he suffered swelling and pain in his left eye, and double vision appeared when his left eye rotated upward, downward, and lateral ward. In other hospitals, after treatment of anti-inflammatory and hemostasis, the symptom of double vision was not improved significantly, and left eye swelling and pain gradually disappeared. Patient is referred to our department. Examination: In the left eye, visual acuity is 0.8, there is obvious enophthalmos in the left eye, upper eyelid sulcus is obviously deepened (Fig. 10.23), upward rotation of eyeball was slightly restricted (Fig. 10.24), no movement restriction is found in other directions, the cornea is transparent, and exophthalmos is measured as 16 mm in the right eye, 13 mm in the left eye, and orbital distance 110 mm. Intraocular pressure and orbital pressure were normal. Preoperative CT scan showed that the left medial orbital wall and infraorbital wall were fractured, the medial rectus muscle and the inferior rectus muscle were edematous and displaced, the orbital tissue herniated into the maxillary sinus and ethmoid sinus, and the inferior rectus muscle was embedded in the maxillary sinus (Figs. 10.25 and 10.26). Under general anesthesia, the left orbital fracture was repaired by surgery, and the orbital

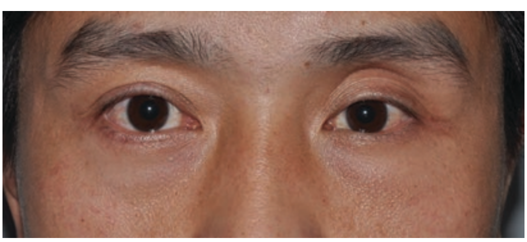

Fig. 10.23 Three months after the left orbital was injured by someone else's elbow, there is obvious enophthalmos in the left eye, and the upper eyelid sulcus is obviously deepened

Fig. 10.24 Three months after the left orbital was injured by someone else's elbow, there is obvious enophthalmos in the left eye, and upward rotation of eyeball was slightly restricted

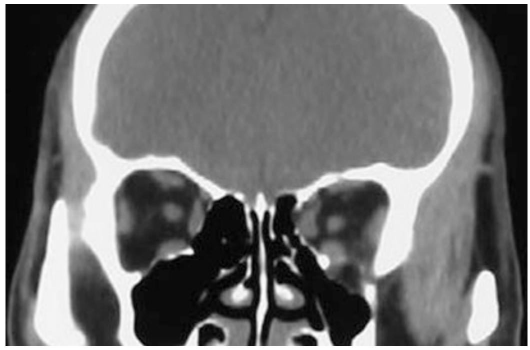

Fig. 10.25 Preoperative CT scan showed that the left medial orbital wall and infraorbital wall were fractured, the medial rectus muscle and the inferior rectus muscle were displaced, and the orbital tissue herniated into the maxillary sinus

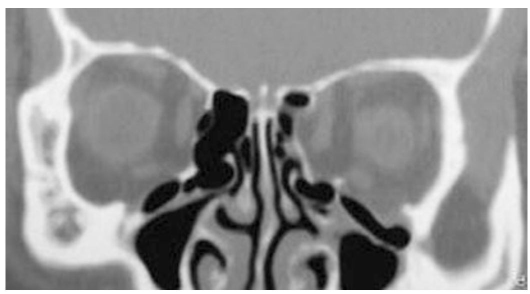

Fig. 10.26 Preoperative CT scan showed that the left medial orbital wall and infraorbital wall were fractured, the orbital tissue herniated into the maxillary sinus and ethmoid sinus, and the medial rectus muscle and the inferior rectus muscle were edematous and displaced

fat, the inferior rectus muscle, and the medial rectus muscle that herniated into the maxillary sinus and ethmoid sinus were restored to the orbital cavity. The procedure includes exposing the four walls of the fracture area, implanting a

preformed titanium mesh into the lower part of the orbit, adjusting the position, fixing it with the titanium nail, filling a wedge-shaped body on the preformed titanium mesh, increasing the orbital volume, completely correcting the enophthalmos, and pulling the medial rectus muscle and the lower rectus muscle without resistance. CT showed that the titanium mesh was implanted into the orbit after the left orbital lower wall fracture, the orbital structure was restored, and the titanium mesh was in good position (Figs. 10.27 and 10.28). Postoperative appearance showed that the enophthalmos was completely corrected and the eyeball movement in all directions was normal (Figs. 10.29 and 10.30). No recurrence was found in the follow-up for half a year.

Fig. 10.27 Postoperative CT showed that the titanium mesh and hydroxyapatite wedge-shaped fill which is soaked with iodized oil were implanted into the left orbit, the orbital structure was restored, and the titanium mesh was in good position (*left front view*)

Fig. 10.28 Postoperative CT showed that the titanium mesh was implanted into the left orbit, the orbital structure was restored, the titanium mesh and hydroxyapatite wedge-shaped fill which is soaked with iodized oil were in good position (front view)

10.5.2 Tips and Pearls

Orbital medial and inferior wall fractures usually easy to involve a wide range, the corner, also called ethmoid-maxillary support structure, single bone plate is difficult to restore the orbital structure [7], and preformed titanium mesh can restore the orbital wall and inferior wall structure after fracture to the greatest extent [8, 9]. Orbital fracture can be combined with a variety of ocular trauma, should be particularly stressed that even if there is no vision decrease, should also be via intraocular pressure, fundus and imaging examination to determine whether the existence of eyeball injury, any threat to vision of eye injury,

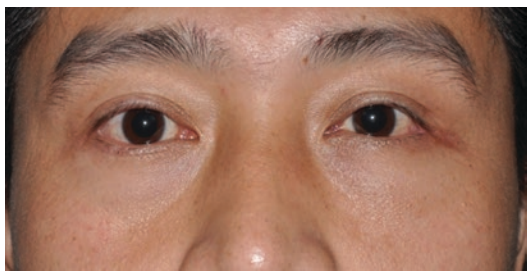

Fig. 10.29 Postoperative appearance shows that the enophthalmos of the left eye was completely corrected and the eye moves normally in all directions (when looking forward)

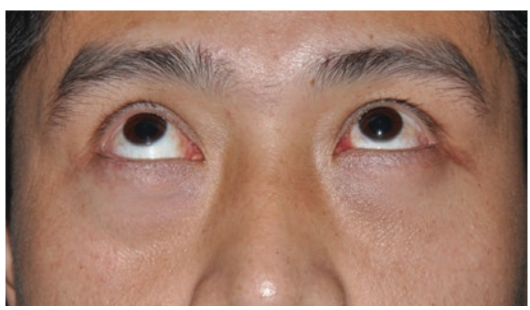

Fig. 10.30 Postoperative appearance shows that the enophthalmos of left eye was completely corrected and the eye moves normally in all directions (when looking upward)

should give priority to treatment, orbital fracture should be repaired in stable condition.

The most common surgical approach is the conjunctival incision on the lower margin of the lower Meibomian plate [10, 11]. If only the fat around the extraocular muscle or some fascia tissue outside the muscle is clamped by the fracture fissure, the operation is not difficult and just to separate the tissue in the fissure and return to the orbit. Fracture area was too small to even require implantation of orbital wall repair material. Trapdoor fractures and flap fractures in children have impacts on the inferior rectus muscle. The muscle holding fracture pieces should be pushed into the maxillary sinus with an aspirator or stripper on both sides of the inferior rectus muscle, and then the muscle should be pulled out of the enlarged bone defect. Do not forcibly pull the muscles.

Children trapdoor fracture is a common fracture because of its good orbital bone elasticity, which is also a cause of muscle impaction. Orbital floor and medial wall fractures, at the same time, diplopia, and other symptoms are more complex. Trapdoor fracture is a small fracture of the orbital wall in which one edge is continuous with the normal bone wall, the other edge, such as a flap-like rebound, closes the fracture, and the extraocular muscle or surrounding tissue is retained [12, 13]. Craniofacial development of children and adolescents, which is the main affected population, mostly occurred in the infraorbital wall and rare in the medial wall [14, 15]. If this fracture is not treated in time, the embedded extraocular muscle or soft tissue may become necrotic and scarred due to ischemia [16, 17].

10.6 Case #5: Orbital Zygomaticomaxillary Complex Fracture

10.6.1 Case Description

A 23-year-old man, who was hit by someone with a brick 3 months ago on the left orbit, head, and face, was in a coma, was rushed to a nearby hospital for neurosurgery treatment, and was diagnosed as craniocerebral injury, eyeball injury, orbital and cheek injury; detumescence and hemostasis treatment was given. He was sober 3 days later and discharged from hospital for 13 days. The head injury and eyeball injury recovered well. Due to the collapse of the left orbitozygomatic face, the eyeball is sunken (Figs. 10.31, 10.32, and 10.33), affecting the appearance, and was referred to our department. Three-dimensional reconstruction of the CT showed left orbital zygomatico-maxillary complex fracture, left orbital cavity expansion, zygomatic fracture, frontal zygomatic process, and maxillary frontal process fracture, and there were a number of free bone fragments (Figs. 10.34 and 10.35). Diagnosis: left orbital complex fracture (orbital-zygomatic-maxilla fracture), left orbital facial collapse, zygomatic collapse, enophthalmos, and left temporal scar. Orbital fracture repair operation under general anesthesia, operation from the lower eyelid margin skin incision, horizontal temporal extension, and removal of the free bone fragment, lateral maxilla, and zygomatic completely comminuted fracture. Lateral orbital margin of large pieces of broken bone splicing, with titanium plate and titanium nail fixation, orbital margin defect of about 1.0 cm, reconstruction of orbital margin with titanium plate, both ends fixed to the frontal zygomatic process and maxilla end, reconstruction of orbital cavity and orbital margin, and reconstruction of maxilla and maxillofacial region after titanium mesh trimming. The orbital adipose tissue and inferior rectus muscle which were hernia into maxillary sinus were returned into the orbit, and the large titanium mesh was cut and placed above the fracture area. The fracture area was completely closed, and the inferior and orbital outer walls were reconstructed. The enophthalmos was completely corrected. Three-dimensional reconstruction CT showed that after the operation of left orbital zygomatic complex fracture, titanium mesh was implanted into the orbit to reconstruct the orbital rim, orbital cavity was reconstructed (Figs. 10.36 and 10.37), left zygomatic facial collapse was completely corrected, zygomatic collapse was completely corrected, and eyeball rotation recovery was satisfactory (Figs. 10.38, 10.39, 10.40, and 10.41).

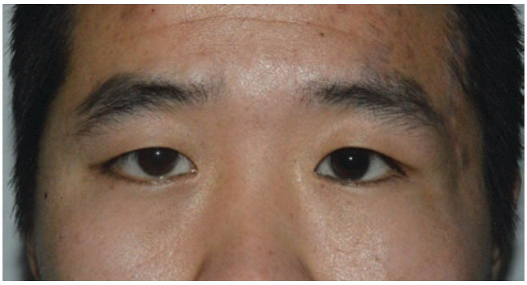

Fig. 10.31 Orbital zygomaticomaxillary complex fracture in the left eye, a collapse of the left orbitozygomatic face, enophthalmos

Fig. 10.32 Orbital zygomaticomaxillary complex fracture in the left eye, a collapse of the left orbitozygomatic face, enophthalmos (when look leftward)

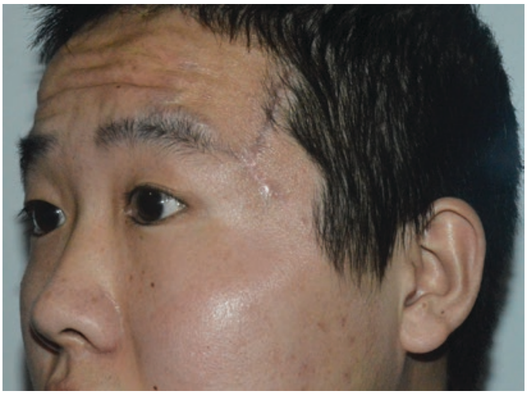

Fig. 10.33 Orbital zygomaticomaxillary complex fracture in the left eye, a collapse of the left orbitozygomatic face, enophthalmos (*left front view*)

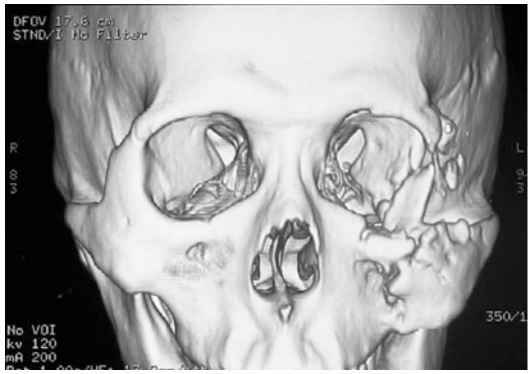

Fig. 10.34 Three-dimensional reconstruction of the CT showed left orbital zygomaticomaxillary complex fracture, left orbital cavity expansion, zygomatic fracture, frontal zygomatic process, and maxillary frontal process fracture, and there were a number of free bone fragments (*front view*)

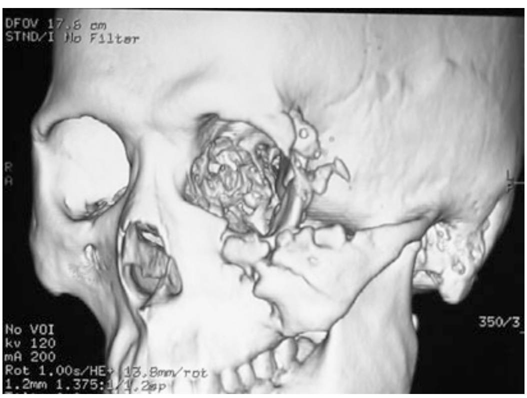

Fig. 10.35 Three-dimensional reconstruction of the CT showed left orbital zygomaticomaxillary complex fracture, left orbital cavity expansion, zygomatic fracture, frontal zygomatic process, and maxillary frontal process fracture, and there were a number of free bone fragments (*left front view*)

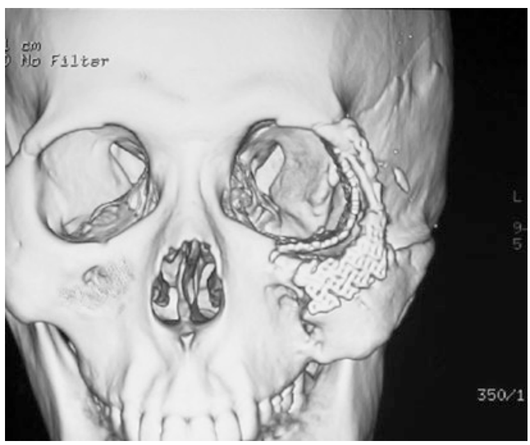

Fig. 10.36 After surgery, three-dimensional reconstruction CT demonstrating titanium mesh implantation, reconstruction of the orbital rim, titanium mesh implantation into the orbit, and reconstruction of the orbital cavity (*front view*)

Fig. 10.37 After surgery, three-dimensional reconstruction CT demonstrating titanium mesh implantation, reconstruction of the orbital rim, titanium mesh implantation into the orbit, and reconstruction the orbital cavity (*lateral view*)

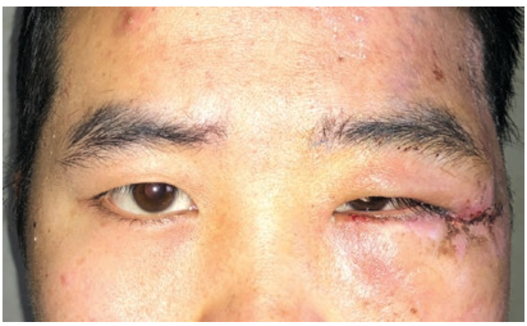

Fig. 10.38 Left zygomatic facial collapse was completely corrected, and zygomatic collapse was completely corrected (*front view*)

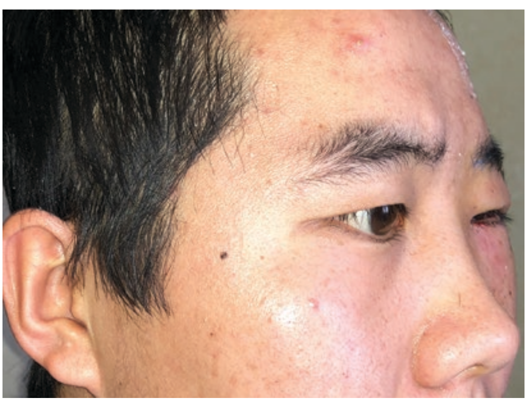

Fig. 10.39 Left zygomatic facial collapse was completely corrected, and zygomatic collapse was completely corrected (*right lateral view*)

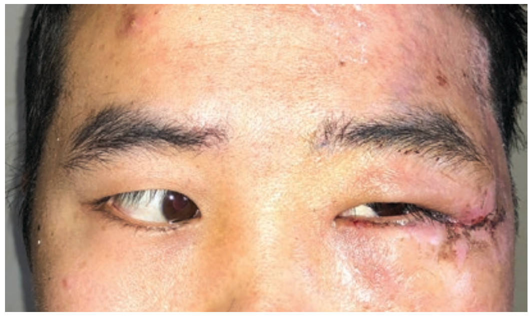

Fig. 10.40 Left zygomatic facial collapse was completely corrected, zygomatic collapse was completely corrected, and eyeball rotation recovery was satisfactory (*when look leftward*)

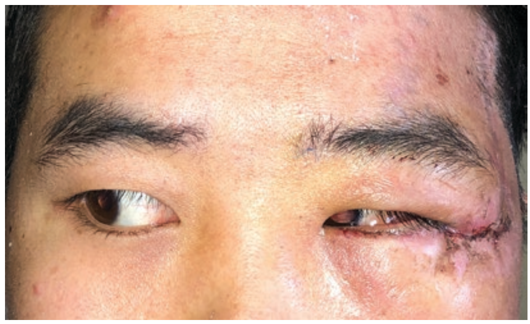

Fig. 10.41 Left zygomatic facial collapse was completely corrected, zygomatic collapse was completely corrected, and eyeball rotation recovery was satisfactory (*when look rightward*)

10.6.2 Tips and Pearls

Complex fractures are mainly found in various traffic accidents, falling injuries, or serious facial injuries. Clinical manifestations are multiple facial fractures, and severe fractures can be combined with extraocular muscle laceration. Complex fracture is a severe trauma, often combined with craniocerebral injury, cerebrospinal fluid leakage, and coma, and skull base fracture is more common. Complex fracture is often seen in orbital zygomatic fracture and nasal-orbital-ethmoidal fracture.

Orbital zygomatic fracture is the most common complex fracture. Zygomatic body because of its large volume, located in the lateral middle of the face, is a site susceptible to collision, the direction of external force action is different, and the direction of zygomatic body displacement and the corre-

sponding clinical manifestations are also different. Zygomatic body temporalward and downward displacement can make the orbital cavity expanded, zygomatic facial collapse, facial asymmetry, enophthalmos, and downward displacement; the malar bone body was displaced backward, showing the collapse of malar temporal and lateral canthus. The malar bone body was displaced medialward, and the orbital cavity was reduced. Forward displacement manifested as zygomatic eminence [9].

Most orbital fractures have diplopia to some extent in the early stage but can recover spontaneously without muscle impaction. Early use of small doses of corticosteroids to alleviate tissue edema is preferred. Surgical indications include persistent diplopia (extraocular muscle impaction) and significant enophthalmos. Imaging examination showed that extraocular muscle impaction should be performed early, especially in children with orbital floor fracture, more than 2 weeks may cause muscle degeneration, the effect is not good, and recovery is slow. Generally, surgery can be mastered within 2 months after trauma, but in long-term diplopia, surgical repair also has a certain effect. More than 3 mm eyeball invagination was repaired by the operation. The principle of surgical correction of enophthalmos is that the closer to the orbital apex, the better the correction effect of enophthalmos, but the greater the risk. Overfilling in front of the equator causes the eye to shift to the opposite side rather than to protrude.

10.7 Case #6: Orbital Foreign Body Injury

10.7.1 Case Description

A 44-year-old man was admitted to the hospital for he was spattered with foreign body which hurt the left eye at work 10 days ago. After injury, his left eye was bleeding and swelling, and he could not open the eye and was rushed to the local hospital; the diagnosis was left orbital foreign body injury. Under local anesthesia, left eyelid wound was sutured but failed to remove the foreign body. The patient was referred to our hospital for further diagnosis and treatment. Examination: left eye, visual acuity 1.0, left eye eyelid edema, visible wound in the upper eyelid skin, about 6 mm long and sutured (Fig. 10.42). Eye position is normal, and eye movement in all directions was unrestricted (Figs. 10.43 and 10.44), Measurement of exophthalmos: 15 mm in the right eye, 15 mm in the left eye, and orbital distance, 112 mm. Conjunctival congestion, corneal transparency, intraocular pressure and orbital pressure was normal. CT scan of the orbit showed that the left orbital margin was adjacent to the high-density metal foreign body shadow (Figs. 10.45, 10.46, and 10.47). Three-dimensional reconstruction CT showed irregular metallic foreign body, on the medial margin of the left orbit (Figs. 10.48 and 10.49). Diagnosis: left orbital metallic foreign body. Under local anesthesia, the left orbital foreign body was removed. Skin incision was made in the left eyebrow arch, about 1.5 cm long, and a metal foreign body was found under the superior oblique muscle. A large amount of rust and necrotic tissue were found around the wound. The foreign body was separated and completely removed, about 11 × 2 × 2 mm. Postoperative 1-week review, left eye, vision 1.0, normal eye rotation in all directions, wound healing (Fig. 10.50), and normal orbital pressure.

Fig. 10.42 Orbital foreign body injury in the left eye, eyelid edema, visible wound in the upper eyelid skin visible a wound, about 6 mm long and sutured

Fig. 10.43 Orbital foreign body injury in the left eye, eyelid edema, visible wound in the upper eyelid skin, about 6 mm long and sutured (*when look leftward*)

Fig. 10.44 Orbital foreign body injury in left eye, eyelid edema, visible wound in the upper eyelid skin, about 6 mm long and sutured (*when look rightward*)

Fig. 10.45 Orbital horizontal CT scan showed that the left orbital margin was adjacent to the high-density metal foreign body shadow

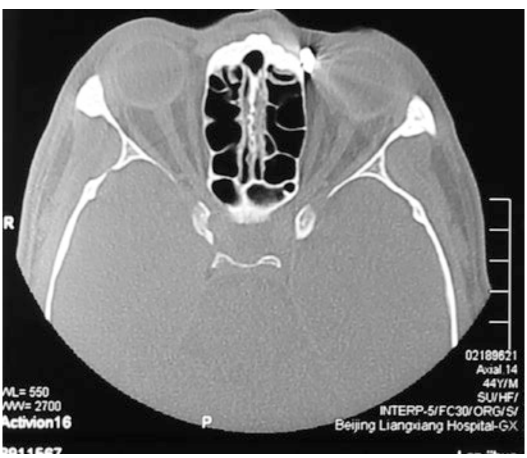

Fig. 10.46 Orbital bone window CT showed that the left orbital margin was adjacent to the high-density metal foreign body shadow

Fig. 10.47 Orbital coronal CT showed that the left orbital margin was adjacent to the high-density metal foreign body shadow

Fig. 10.48 Three-dimensional reconstruction CT showed irregular metallic foreign body, on the medial margin of the left orbit (*front view*)

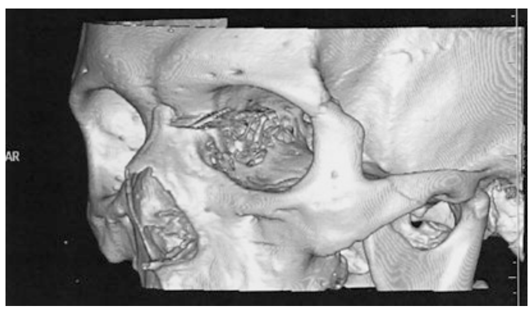

Fig. 10.49 Three-dimensional reconstruction CT showed irregular metallic foreign body, on the medial margin of the left orbit (*left front view*)

Fig. 10.50 Postoperative 1 week review, normal eye rotation in all directions, wound healing

10.7.2 Tips and Pearls

Most of the orbital foreign bodies enter the orbit through the region between the eyeball and orbital wall and rarely enter the orbit through the eyeball by perforating. Occasionally through the paranasal sinuses into the orbit, if the injury is large and sharp, they could also enter directly into the orbit through the orbital lateral wall. According to the types of foreign bodies, orbital foreign bodies are divided into metallic foreign bodies and nonmetallic foreign bodies; the latter is divided into nonirritating foreign bodies and irritating foreign bodies. Nonirritating foreign matter is a kind of chemically stable substances and generally does not cause tissue reaction, such as glass, stone, plastic, etc. Irritant foreign bodies include vegetable foreign bodies and various chemical oils. Irritating foreign bodies can cause serious tissue reactions or purulent inflammation and even lead to fistula formation. If some foreign bodies are not removed in time, residual orbital infection or fistula should form, and serious one might endanger vision, even life-threatening. The long course of plant foreign body, in the surrounding tissue, and secondary suppurative inflammation, at the same time, also can form a mechanical package and bring difficulties to detect foreign bodies. Orbital foreign body patients who deny the history of the injury and have no obvious appearance scar make the diagnosis more difficult. It is common in children with unclear language expression and drunk or confused consciousness. Doctors should pay more attention to the orbital foreign body as one of the differential diagnos is for unknown causes of redness, sinus formation, or imaging abnormalities.

Orbital foreign body as a special type of open orbital trauma and its clinical manifestations vary according to the nature of the foreign body, including metal foreign body which is the most common, but the clinical diagnosis of nonmetallic foreign body variety, in complex and diverse conditions, is difficult and needs to be combined with a variety of imaging examination and comprehensive analysis. Nonspecific clinical manifestations were associated with occupancy effects, mechanical injury, and rejection of foreign bodies. But the clinical manifestation is often caused by a combination of factors, such as eye movement disorder which can be caused by mechanical damage of extraocular muscles or oculomotor nerve and may also be a huge foreign body which hinders the eye movement or extraocular muscle contraction; muscle scar adhesion can also lead to eye movement restriction disorders.

Preoperative examination of orbital metallic foreign bodies is very important. X-ray: metal foreign matter or glass high-density foreign matter. X-ray can show its position, shape, and the depth and number of foreign matter. Metal foreign bodies are displayed in various shapes such as irregular or circular shape on the X-ray, and the boundary of the foreign bodies is clear. CT can not only show the shape and number of foreign bodies but also show the soft tissue around the foreign bodies and also show the relationship between foreign bodies and surrounding structures. MRI is a contraindication to metallic foreign bodies. MRI examination of nonmetallic foreign bodies is a supplement to CT examination; especially wooden foreign bodies are shown as no signal shadow on MRI, and high signals around the foreign bodies indicate edema and/or hemorrhage of tissues. The X-ray of the plant foreign body is not helpful; it only can show the density increase in the orbit. Plant foreign body, such as large wooden foreign body, generally early on CT for low-density shadow, and late foreign body absorbed tissue fluid, and pus density increased and can be a soft tissue mass shadow. Foreign body and the surrounding granulation tissue package density is consistent and could not be identified on CT. Ultrasonic examination of the presence of plant foreign bodies in the orbit can be manifested as a strong echo spot, spot, or band of light with different shapes in the hypoechoic region of the orbit. MRI showed no signal streaks, which could be clearly distinguished from the pus, granulation, scar, and normal orbital tissue. Therefore, it is suggested that ultrasound and/or MRI should be supplemented for the diagnosis of suspected residual plant foreign bodies to prevent misdiagnosis.

The treatment principles of orbital foreign body: Orbital foreign body types are different,

the treatment method is also different. Metal foreign bodies in the orbit because of the orbital soft tissue package mostly don't have to be taken out, unless they affect the eye movement, or foreign bodies near the optic nerve may affect the vision. Glass foreign bodies that with no infection may not be removed. Plant foreign bodies can cause soft tissue inflammation and fistula and must be removed by surgery. It should be noted that the complete removal of foreign bodies is not the end of clinical treatment but only the premise, eyelid plastic surgery and strabismus surgery often need to be completed in the second stage. It is important to develop an individualized multistage surgical repair plan for orbital wall fractures combined with intraocular structural injuries.

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11 Traumatic Optic Neuropathy

Yun Zhang and Meixia Zhang

Abstract

Traumatic optic neuropathy (TON) refers to any injury to the optic nerve secondary to trauma. Injury may be direct or indirect and visual loss may be partial or complete. Direct TON results from an anatomical nerve disruption by penetrating orbital trauma. Indirect injury results from transmission of forces to the nerve. The prognostic value in knowing that an injury was direct or indirect is unclear, and the mechanism of injury is not understood. Also, there are no confirmed protocols for prevention, mitigation, or treatment. Current therapeutic modalities include observation alone, systemic high-dose corticosteroid administration, and/or surgical optic nerve decompression. This chapter includes four cases with brief descriptions, illustrating figures and personal tips and pearls, aiming to provide a guide of diagnosis and management of traumatic optic neuropathy.

Keyword

Traumatic optic neuropathy

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11.1 Introduction

Traumatic optic neuropathy (TON) is a clinical diagnosis when there is evidence of optic neuropathy following a history of a blunt or a penetrating trauma. This condition may be associated with multisystem trauma especially head injury which needs attention first. The location of trauma-induced injury to the optic nerve can occur anywhere along the nerve's intraorbital to intracranial length. Approximately 0.5–5% of patients with closed head injuries have damage to the visual pathways [1, 2] and 2.5% of patients with midfacial fracture. Eighty-five percent of patients with TON are seen in middle-aged males. The majority of TON causes are motor vehicles and bicycle accidents followed by falls and assaults. TON also can be diagnosed with penetrating trauma (stab wounds, gunshot wounds, foreign bodies) and recreational sports (e.g., paintball injury).

Optic nerve injuries are classically divided into two categories [3]: direct and indirect trauma. Direct trauma results from a tear of the optic nerve itself or a tear caused by a fracture fragment or other foreign body, as well as a compression injury caused by a fracture of the optic canal, intraorbital or intrathecal hemorrhage. Forehead trauma is the most common, especially the contusion of the lateral brow arch. It is supposed to be related to the damage caused by shear force acting on the optic nerve

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or the attachment point of the trophoblastic vessels in the optic nerve canal. Based upon fundus features, TON can be divided into anterior optic neuropathy, posterior optic neuropathy, and optic disc avulsion. Optic disc change that can be found in fundus examination is called anterior indirect trauma, while the most common is posterior indirect trauma in clinic, which is traumatic loss of vision which occurs without external or initial ophthalmoscopic evidence of injury to the eye or its nerve. The avulsion of the optic nerve is caused by the extreme rotation and forward displacement of the eyeball or extrusion that causes sudden increase in intraocular pressure resulting in rupture of the sieve plate; or the optic nerve is pulled backward by an orbital perforation injury, which causes the optic nerve to be strongly pulled back from the scleral canal and a backward dislocation.

During craniocerebral trauma, force applied to the superior orbital rim can be transferred and concentrated on the orbital roof and optic canal. The resultant percussive forces can damage the nerve at transitions between mobile and fixed segments. This commonly occurs at the junction of the intraorbital and intracanalicular segments and results in compression and disruption of pial vessels within the canal, affecting vascular supply of the optic nerve.

Due to an immediate disruption (direct trauma) or mechanical shearing (indirect trauma) to the optic nerve, the primary damage then occurs. Following inflammation and vascular dysfunction gives rise to the secondary damage. Though the primary and secondary pathophysiologic mechanisms of injury differ greatly, patients often suffered damages of both.

The management of TON should be a multidisciplinary approach involving the ophthalmologist, physician, neurosurgeon, and an otorhinolaryngologist. The treatment of TON is somewhat controversial. The optimum management protocol is yet to be elucidated as there is paucity of prospective large-scale clinical trials. The International Optic Nerve Trauma Study was organized to help clarify the value of different treatments of TON, since the natural prognosis of traumatic optic neuropathy is generally poor. Different TON should be given different treatment, but for optic nerve laceration and optic nerve head avulsion, there is no effective treatment. For optic nerve sheath hematoma, optic nerve sheath fenestration may be helpful in the acute stage if optic neuropathy is progressing and no other cause is evident. Effective treatment of posterior indirect TON is, at best, extremely limited. In the vast majority of cases, observation alone is recommended. High-dose corticosteroids should never be offered by ophthalmologists to patients with concomitant traumatic brain injury (TBI) or if the TON is older than 8 h. If steroids are considered (no evidence of TBI, injury within 8-h window, no medical comorbidities), the lack of definitive therapeutic evidence and significant side effects must be discussed with the patient and/or family and the primary team. And for the bone impingement of the optic canal, endoscopic optic canal and orbital apex decompression may be offered in select cases, especially if the optic neuropathy is progressive. However, this option should be approached with extreme caution because of the proximity to the cavernous sinus and carotid siphon and possible bony instability of the skull base. The procedure should only be performed by an otolaryngologist experienced in stereotactic endoscopic sinus and skull base surgery. The patient and/or family should also be informed that there is no definitive data that proves efficacy of this procedure in TON and that optic canal decompression may result in additional damage to the intracanalicular optic nerve.

11.2 Case #1: CRAO and CRVO in a Case of TON

11.2.1 Case Description

A 17-year-old man was struck in the left eye while playing football, and he immediately experienced severe loss of vision in the eye. On examination of the left eye, vision was no

light perception (NLP). The intraocular pressure was 16.5 mmHg. The pupil was round and reacted consensually but not directly to light. Relative afferent papillary dilatation (RAPD) was positive. Fundus examination showed white-out retina and a cherry-red spot at the macula (Fig. 11.1). Computed tomography (CT) scan of orbit showed that the optic nerve was bulky and no evidence of bony fracture (Fig. 11.2). All systemic investigations including cardiology workup were normal. The patient received intravenous bolus therapy with methylprednisolone 1 g intravenously (IV) for 3 days followed by oral prednisolone. The patient subsequently failed to regain any vision in the left eye. On follow-up after 1 month, there was no improvement of vision in the left eye. But during that time, the white-out retina regained its normal color except in the macular area and the area between the optic disc and macula (Fig. 11.3).

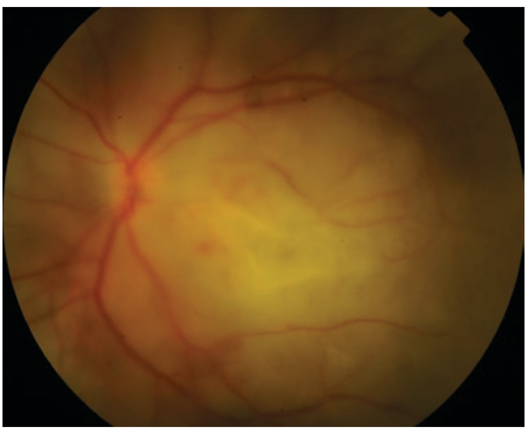

Fig. 11.1 Fundus photograph after 1 day of trauma shows cherry red spot and retinal edema

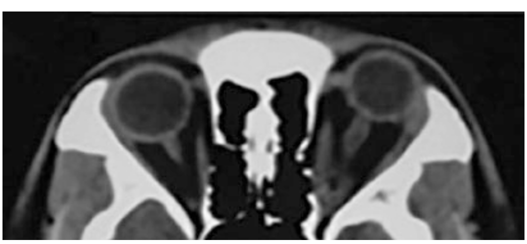

Fig. 11.2 CT scan of orbit shows bulky optic nerve

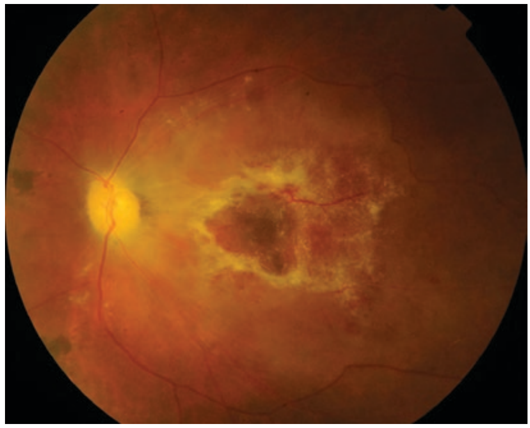

Fig. 11.3 Fundus photograph after 1 month of trauma shows white macula and pale optic disc

11.2.2 Tips and Pearls

Coincident occlusion of CRAO and CRVO is a rare event in ocular trauma. The pathophysiology of the occlusion might be endothelial destruction because of acute extension of retinal vessels caused by sudden trauma and deformations of the eyes. Endovascular rupture is a clear cause of vascular occlusion caused by thrombosis in the human body. Local vasospasm also might be the reason of arterial occlusion and thrombosis, which is a natural steady-state response to trauma [4–6].

It is possible that in some of these cases, the arterial and venous occlusions may not have occurred simultaneously. This case highlights the need for clinicians to be aware of the potential for blunt ocular trauma to cause optic nerve damage and retinal vessel occlusion. And patient with the combination of CRAO and CRVO should be different from the following diseases with systemic disorders, particularly leukemia, hemoglobinopathies, septic cavernous sinus thrombosis, subacute bacterial endocarditis, systemic lupus erythematosus, syphilis, and temporal arteritis, Wegener's granulomatosis, homocystinuria, mitral valve prolapse, atherosclerosis, migraine, sickle cell diseases, Henoch-Schonlein purpura, etc.

11.3 Case #2: A Case with Indirect Traumatic Optic Neuropathy

11.3.1 Case Description

A 71-year-old man accidentally hurt his right eye with a spade while he was working, and immediately right eye bleeding, vision loss, and headache occurred. He was sent to the hospital for a series of eye examinations. On examination of the right eye, visual acuity was 0.02. The intraocular pressure was 36.1 mmHg. The swelling of the right eyelid is obvious, and the upper eyelid is covered by subcutaneous congestion. About 2 mm skin laceration was seen at the proximal canthus, which had been scabbed. Conjunctiva was hyperemia and edema, irregularly laceration of the conjunctiva from the limbus of cornea at 4 o'clock on the nasal side, and suspected scleral laceration at the corresponding location. The nasal corneal epithelium has flap defect and mild corneal edema. The depth of the anterior chamber is different. Partial lens was adjacent to the corneal endothelium. The pupil is not round, obliquely ellipse, and about the size of 4 × 5 mm, and light reflection disappears. The upper equatorial part of the lens is visible in the pupillary area, the lens is opaque, and the remaining structure is not clear. After admission, anterior segment photography showed conjunctival hemorrhage and edema, the pupil not round, and diameter about 8 mm (Fig. 11.4). P-VEP showed P100 latency was delayed at 60′ (60′ was 117 ms) (Fig. 11.5). Type-B ultrasonic showed the choroidal thickening of the right eye (Fig. 11.6). Orbital CT found the right eyelid swelling, eye ring rough and blurred, right anterior chamber shallowed, lens shifted outward and

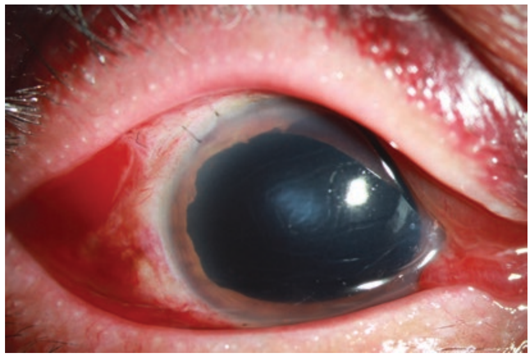

Fig. 11.4 Conjunctival hemorrhage and edema, pupil not round, and diameter about 8 mm

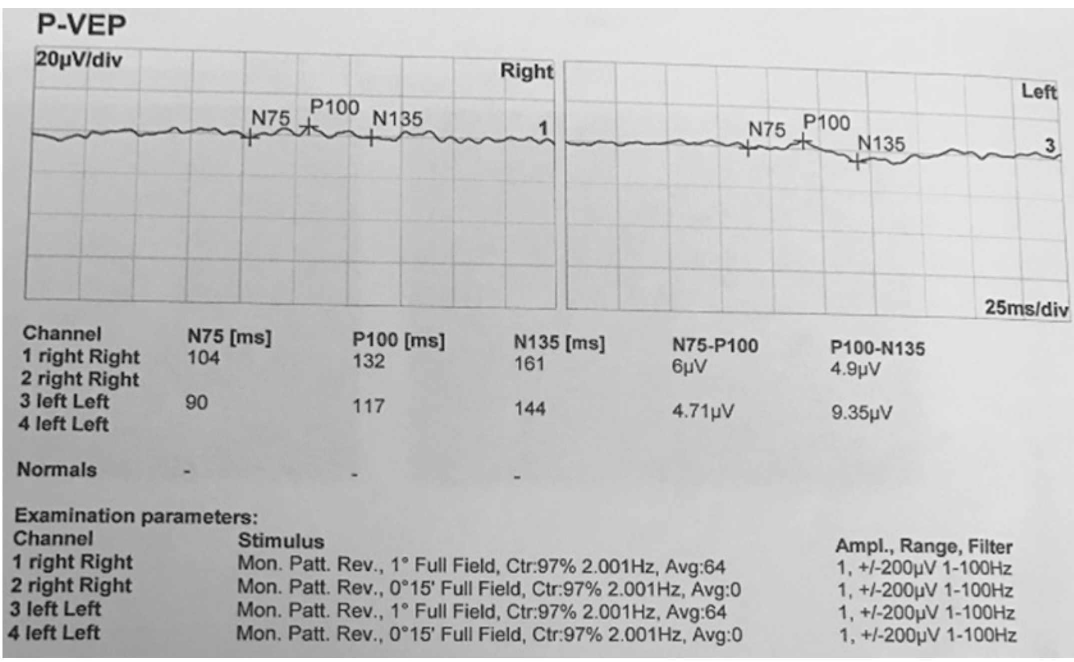

Fig. 11.5 P-VEP showed P100 latency was delayed at 60′ (60′ was 117 ms)

slightly rotated, and no obvious abnormality in the vitreous body. Local suspicious discontinuity of the medial wall of the right orbit, fracture needed to exclude. The right optic nerve is rough, and the medial rectus muscle is slightly rough (Fig. 11.7). The patient was diagnosed with blunt contusion, subluxation of lens, traumatic cataract, secondary glaucoma, and traumatic optic neuropathy in the right eye. The patient received therapy with surgical operation of subluxation of the lens and traumatic cataract in the right eye. Then oral medicines of methycobal and citicoline sodium tablets were given in treatment of TON. Now, the patient is still being followed up.

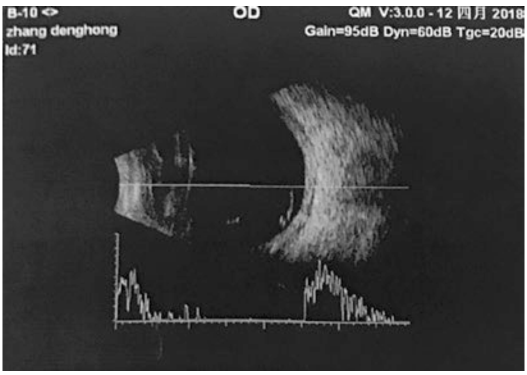

Fig. 11.6 Type-B ultrasonic showed the choroidal thickening of the right eye

11.3.2 Tips and Pearls

According to the definition, indirect traumatic optic neuropathy is a condition that can be clinically diagnosed as optic nerve injury. The patient had a typical history of trauma and clinical feature of visual impairment, dyschromatopsia, visual field impairment, visual evoked potential abnormality, and relative afferent pupillary defect (RAPD).

It is worth noting that RAPD (+) may not exist in patients with binocular optic nerve damage. The optic nerve may perform normally under direct ophthalmoscope while also may gradually develop to paleness or atrophy. Automated computer visual field should also be tested clinically; however, it is possible that the patient's vision is too poor to get valuable results.

In most patients, visual evoked potential (VEP) detection is not required to establish a diagnosis. Especially, VEP may provide confirmatory data and predictive significance where there is an intractable case. In patients with better optic nerve function as reflected in VEP examination, partial or complete recovery of visual acuity is slightly more likely. In addition, VEP may also help in determining treatment options in emergency situations.

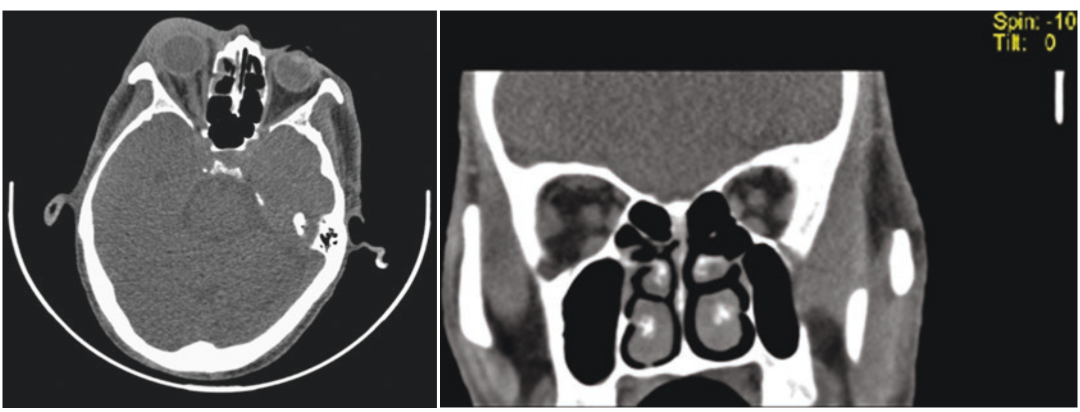

Fig. 11.7 Orbital CT found the right eye eyelid swelling, eye ring rough and blurred, right anterior chamber shallowed, lens shifted outward and slightly rotated, and no obvious abnormality in the vitreous body. Local suspicious discontinuity of the medial wall of the right orbit, fracture needed to exclude. The right optic nerve is rough, and the medial rectus muscle is slightly rough

Several imaging examinations such as CT, MRI, intraorbital ultrasonography, and craniocerebral imaging can help to judge the degree of trauma and can detect other facial or intracranial injuries, hematoma, and orbital bone fragments related to the injury. The ophthalmologic examination should be carried out as early as possible for the patients with coma and craniocerebral injury to discover and treat the optic nerve injury in time.

11.4 Case #3: A Case with Indirect Traumatic Optic Neuropathy

11.4.1 Case Description

An 8-year-old girl was struck in her left eye because of motorcycle injury, and she immediately experienced severe loss of vision in the left eye. She was sent to the emergency ophthalmology for a series of eye examinations. On examination of the left eye, visual acuity was 0.06. Binocular corneal transparency, KP(−), normal anterior chamber depth, AR(−), round pupil and diameter approximately 3 mm, direct light reflection sensitivity. Relative afferent papillary dilatation (RAPD) was present. Binocular lens was transparent and no visible bleeding and exudation. Anterior segment photography showed the left eyelid slightly scraped, the pupil dilated medically, and diameter about 7 mm (Fig. 11.8). Perimetry was generally normal (Fig. 11.9). Type-B ultrasonic, OCT and SLO showed no obvious abnormality (Figs. 11.10, 11.11 and 11.12). But P-VEP showed that P100 latency was obviously delayed at 60′ and 15′ (60′ was 129 ms, 15′ was 155 ms) (Fig. 11.13). The amplitude was reduced compared with the right eye. We gave orbital MRI to the patient, and the result showed the anteroposterior diameter of the left eye is shorter, while the intraocular structure was not abnormal, and the bilateral optic nerve was not thickened or thinned (Fig. 11.14). The diagnosis of indirect traumatic optic neuropathy was made. The patient received intravenous bolus therapy with dexamethasone 15 mg intravenously (IV) for 5 days and afterward gradually reduced to dexamethasone 10 mg intravenously (IV) for 5 days and 5 mg for 5 days, followed by oral methycobal and citicoline sodium tablets for 30 days. One week later, left eye visual acuity was 0.08. Now, the patient is still being followed up.

11.4.2 Tips and Pearls

This case with traumatic optic neuropathy has no direct imaging evidence of optic nerve injury. It has been reported that in 1/3 of the patients with

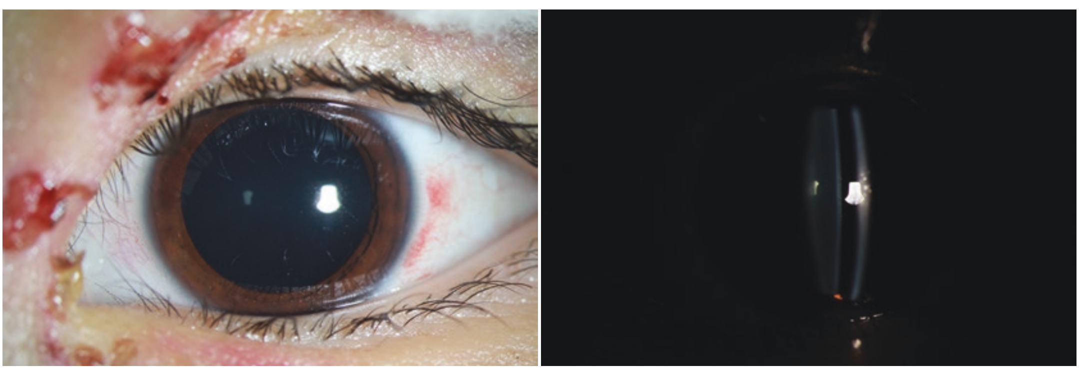

Fig. 11.8 The left eyelid slightly scraped, the pupil dilated medically, and diameter about 7 mm lens was transparent

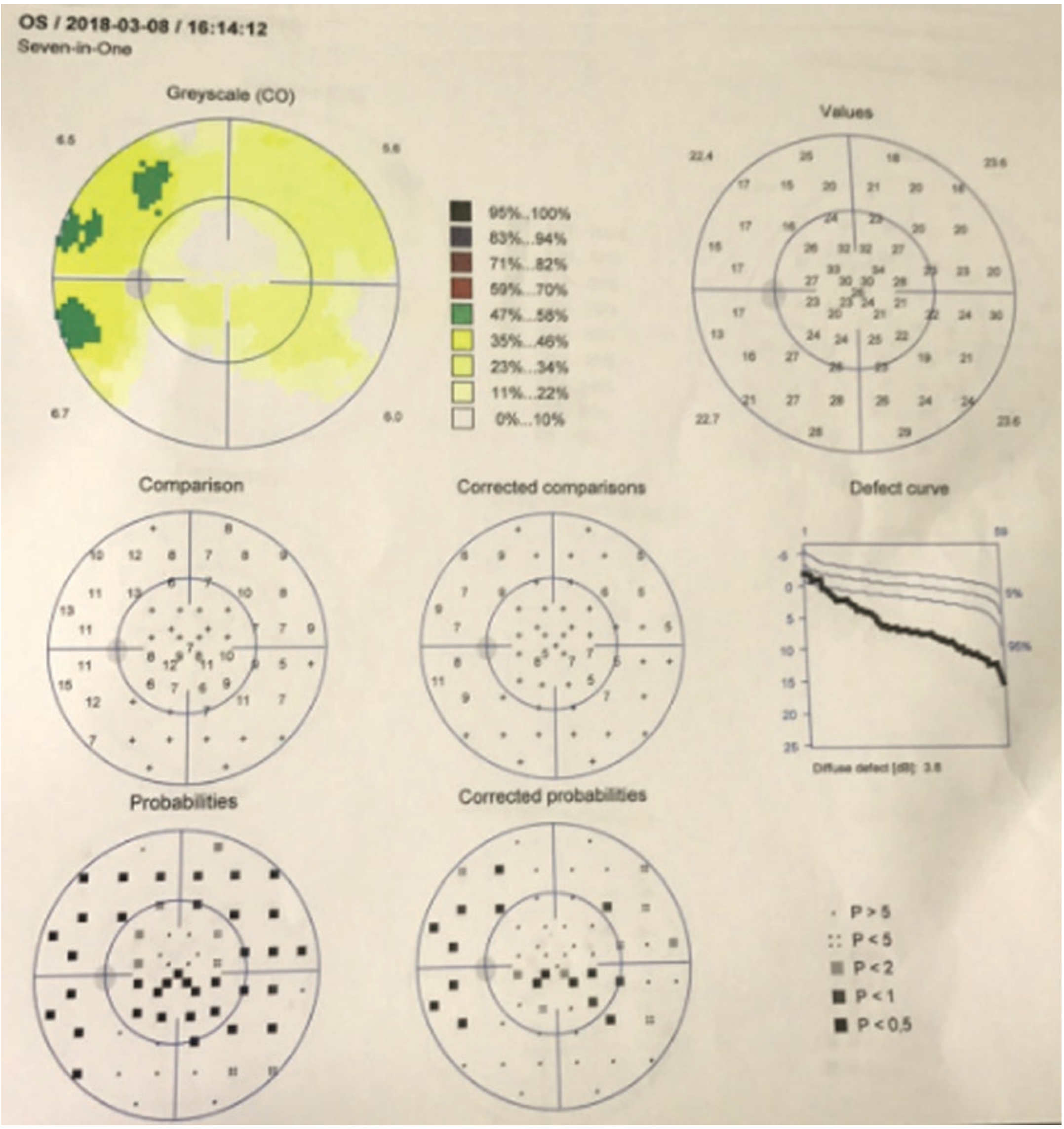

Fig. 11.9 Perimetry was general normal

optic nerve injury, the neuroimaging manifestations were normal, but the visual improvement was slight after treatment.

The optical coherence tomography (OCT) of optic disc is an important examination to evaluate the structure of retinal nerve fiber layer (RNFL). It can evaluate whether the retina around the optic disc of the left eye is thinner than that of the right eye and whether there is a permanent loss of retinal nerve fiber layer. Therefore, we need to follow up regularly for the next 6 months to assess the changes in the visual acuity and disc color of the patient's left eye.

The loss of RNFL, the final result of traumatic optic neuropathy, reveals a common pathological feature: neuronal atrophy and apoptosis.

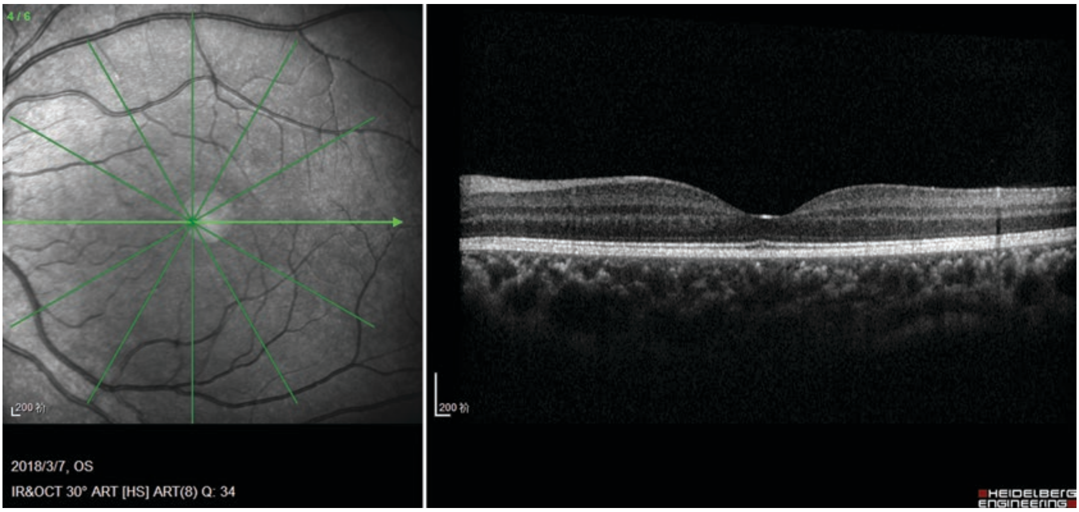

Fig. 11.11 OCT: normal

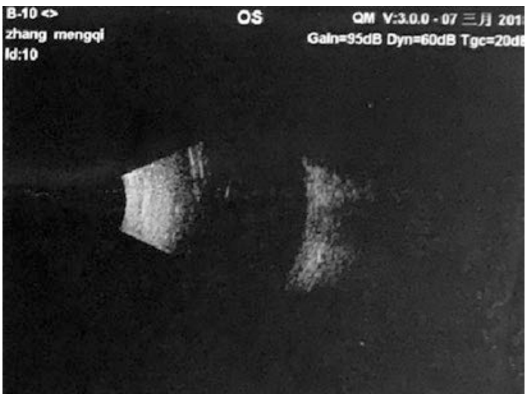

Fig. 11.10 Type-B ultrasonic: normal

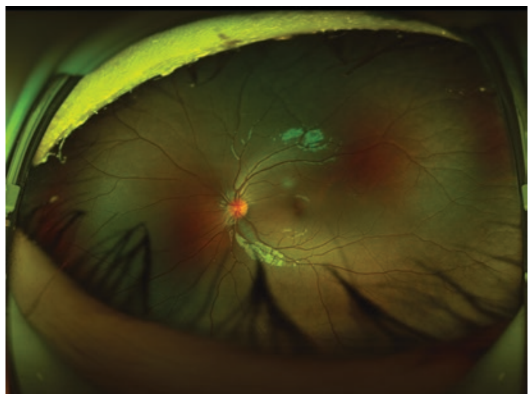

Fig. 11.12 SLO: normal

Traumatic optic neuropathy is a clinical diagnosis; even if only slight head trauma, its symptoms and signs guide doctors to doubt and diagnose traumatic optic neuropathy, with the symbol of visual function loss. Currently, the therapeutic options include temporary observation with nutritional nerve drugs, corticosteroid therapy, surgery of optic nerve decompression, or combination of corticosteroid and optic nerve decompression.

At present, there is no established treatment standard based on the pathophysiological mechanism, but the ischemia and edema in the early stage of the theoretical injury can be prevented in theory. The large dose of the corticosteroid may limit secondary nerve cell injury caused by the generation of the oxygen free radicals, swelling, blood vessel spasm ischemia, and so on.

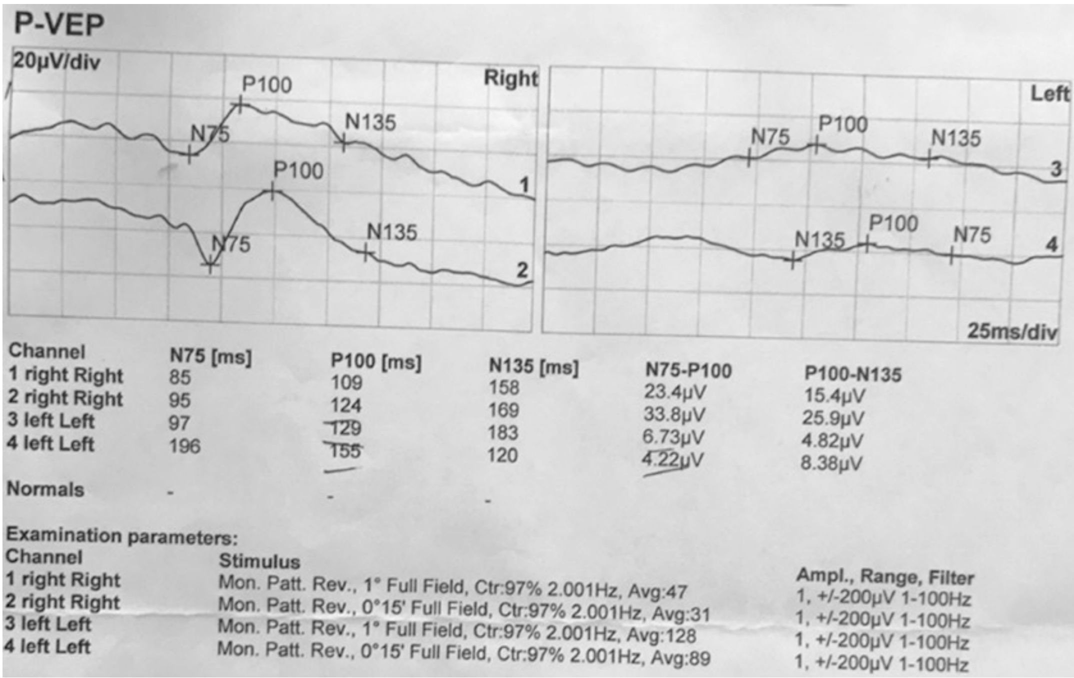

Fig. 11.13 P-VEP showed that P100 latency was obviously delayed at 60′ and 15′ (60′ was 129 ms; 15′ was 155 ms)

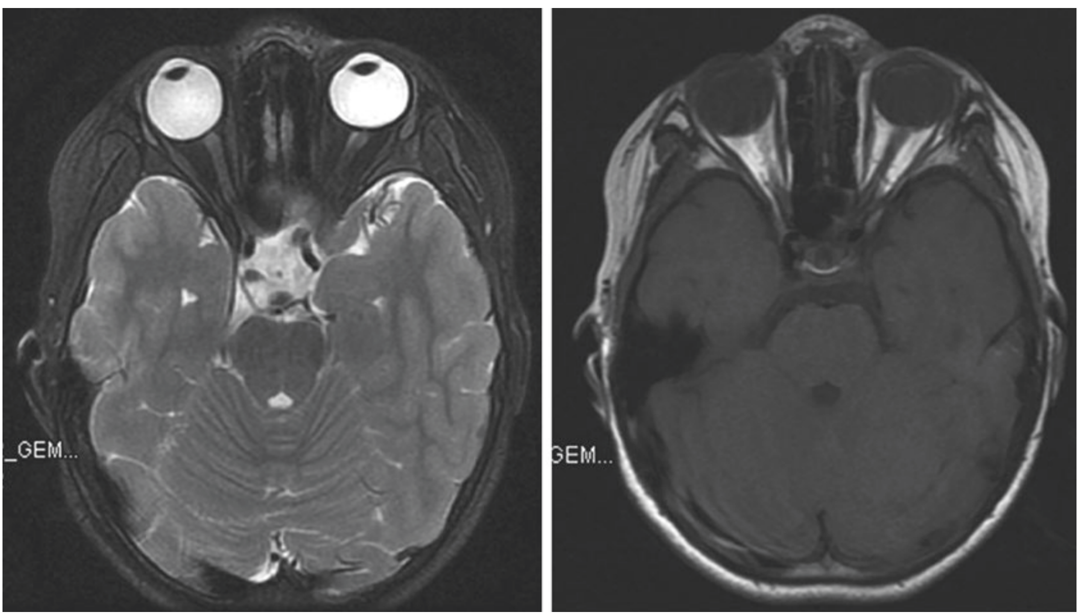

Fig. 11.14 Anteroposterior diameter of the left eye is shorter, while the intraocular structure was not abnormal, and the bilateral optic nerve was not thickened or thinned

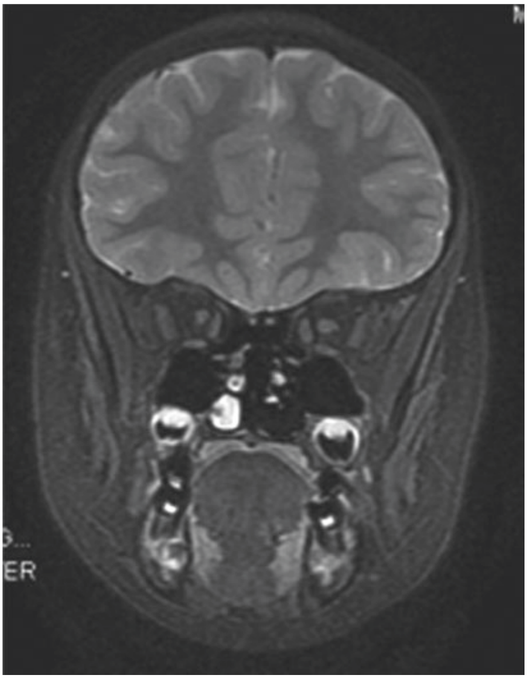

Fig. 11.14 (continued)

11.5 Case #4: A Case with Indirect Traumatic Optic Neuropathy

11.5.1 Case Description

A 26-year-old man was struck in his right eye by a bouncing carrot; his left eye is amblyopic since he was a child. He went to the hospital for a series of eye examinations. Corrected visual acuity of the right eye was 0.8 and 0.2 on the left eye. His right pupil was dilated with traumatic dilation (Fig. 11.15). P-VEP showed that bilateral P100 latency was obviously delayed at 60′ (right is 115 ms, left is 112 ms) (Fig. 11.16). OCT is normal (Fig. 11.17). SLO of the right eye found that there was preretinal hemorrhage on the macular area (Fig. 11.18). The diagnosis of indirect traumatic optic neuropathy and traumatic mydriasis was made. The patient received oral drug therapy of methycobal and citicoline sodium tablets and was recommended to wear sunglasses outside or after surgical treatment.

11.5.2 Tips and Pearls

Traumatic optic neuropathy is a clinical diagnosis, even if there is only a slight history of trauma, but its history combined with symptoms and signs suggest to suspect and diagnose the traumatic optic neuropathy. The main clinical manifestations are as follows: (1) visual acuity decreased, a few patients could maintain their vision, but the severely damaged patients could be reduced to no light perception; (2) visual field defect; (3) abnormal color vision and asymmetry of binocular color perception; (4) most of the patients have the relative afferent pupillary defect; (5) the fundus manifested variously according to the location of injury which can present normal fundus manifestations, optic disc edema, retinal hemorrhage, and so on; and (6) the optic nerve atrophy occurs 3–6 weeks after optic nerve injury, and the loss of visual acuity may be temporary or permanent and partial or complete. For this patient, we need to follow up his visual acuity and retinal nerve fiber layer thickness with optic disc OCT for the next 6 months.

11.6 Treatment

Important signs, examinations, diagnosis, surgical procedures, or postoperative treatment for complications.

Hence, when we diagnose a patient with TON, we should pay attention to the following:

1. History—Mechanism of injury loss of consciousness, nausea and/or vomiting, headache, and clear nasal discharge.
2. Neuroimaging examination—CT and MRI examinations are routine methods for the evaluation of orbital and intracranial injuries.

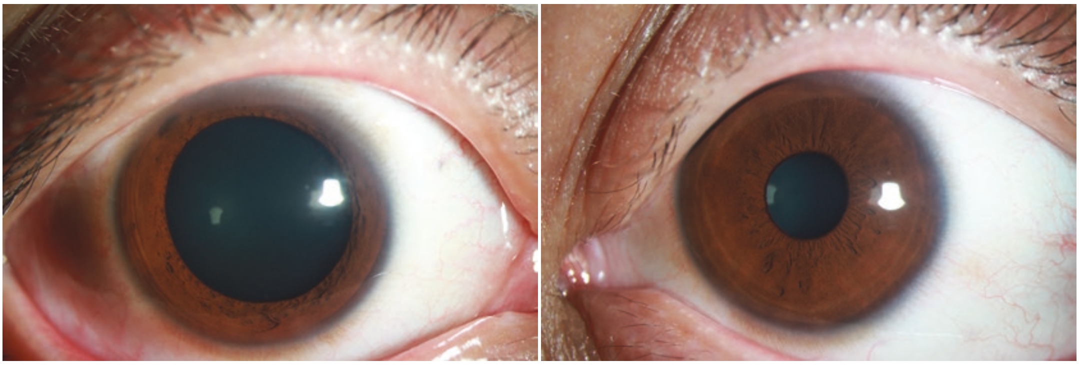

Fig. 11.15 The right pupil was dilated with traumatic dilation

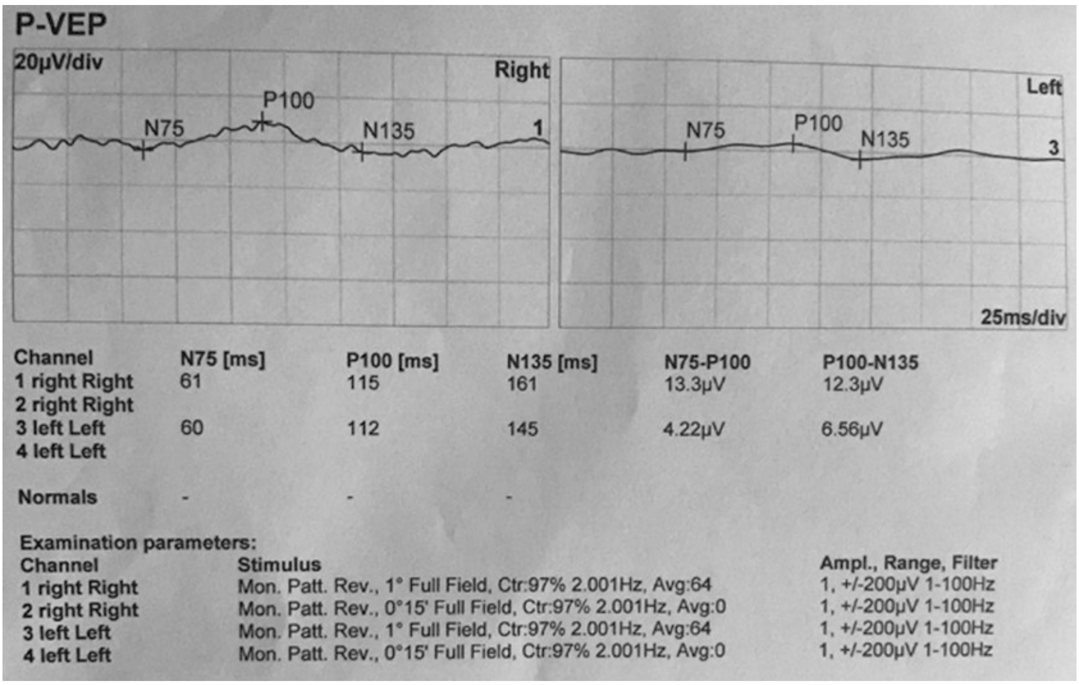

Fig. 11.16 P-VEP showed that bilateral P100 latency was obviously delayed at 60′ (right is 115 ms; left is 112 ms)

CT should be taken first when a metal foreign body is suspected, because the displacement of the foreign body due to the effect of the magnetic field at the time of MRI examination leads to further damage.

3. Visual acuity testing may be difficult depending on the patient's mental status and use of sedatives and narcotics.
4. Pupillary evaluation—Relative afferent papillary defect (RAPD) is the sine qua non in cases of unilateral TON. In the absence of RAPD, either there is no TON or it is bilateral.
5. Color vision—Checking red desaturation is a useful alternative if color plates are not available.
6. Visual fields—Any type of field defects may be seen in optic nerve trauma.
7. Visual electrophysiological examination—VEP, ERG.
8. Fundus examination—Result from objects that penetrate the orbit and impinge on the

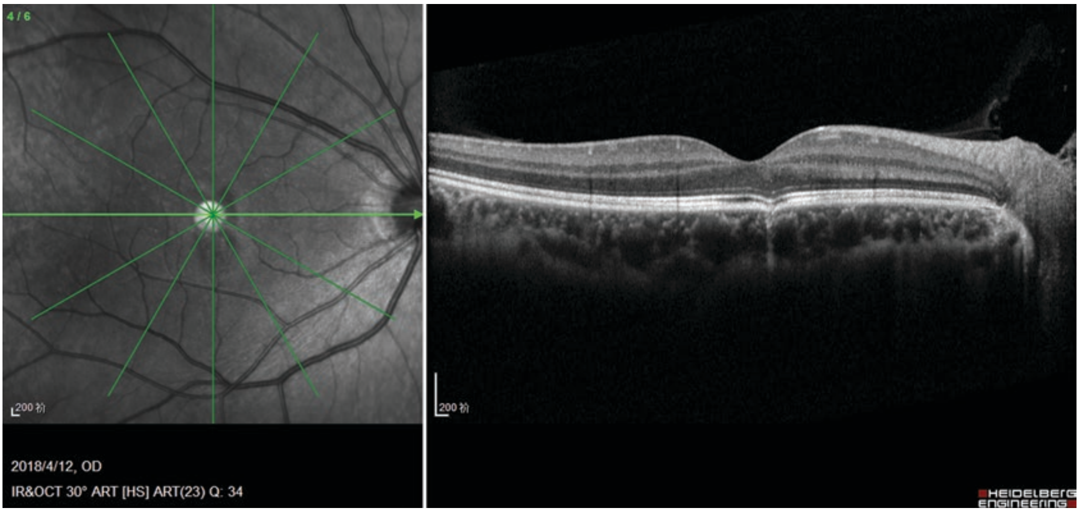

Fig. 11.17 OCT is normal

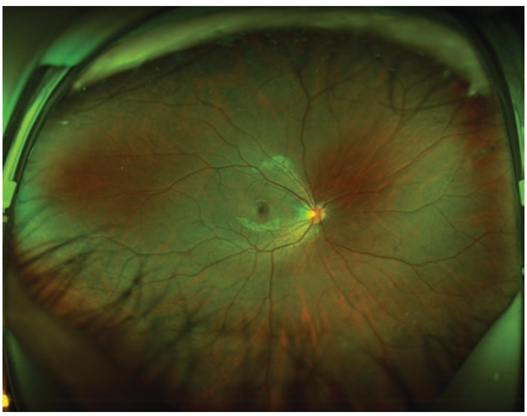

Fig. 11.18 SLO of the right eye found that there was preretinal hemorrhage on the macular area

optic nerve causing optic neuropathy by partial or complete transection of the optic nerve sheath. Hemorrhages within and around the nerve may also occur which lead to immediate changes in the fundus that can be detected on ophthalmoscopic examination.

9. The methods reported in the literature are different, and the clinical results vary greatly, but the consensus is that the earlier the treatment begins, the better the effect. The principles are generally followed: High dose methylprednisolone infusion can be initiated intravenously guttae as soon as possible in acute cases. It is recommended that 500 mg of methylprednisolone per dose be given twice a day. However, some clinical trials compared the effect of intravenous high-dose corticosteroid therapy to placebo for the treatment of recent traumatic optic neuropathy. It was concluded that there was no difference in improvement with the corticosteroid. A study even indicated that high-dose corticosteroids should not be routinely offered to patients suffering a head injury due to an elevated risk of death. After treatment, if visual function is improved, 48 h after intravenous administration can be changed to oral administration, gradually reduced until 2 weeks.
10. If the medication is ineffective after 12–48 h, or the vision is impaired during the reduction process, it is recommended to consider decompression of the optic canal. However, some scholars believe that if glucocorticoid shock therapy is not effective in the early stage of indirect traumatic optic neuropathy, the surgical effect is also very limited. For patients with progressive loss of visual acuity accompanied with fracture of the optic canal and stenosis or fracture into direct optic nerve injury, decompression of the optic canal to relieve compression and injury

should be performed. Opinions for surgical management of traumatic optic neuropathy include partial removal of the bony optic canal (in cases of optic canal fracture fragments impinging the optic nerve), optic nerve fenestration, and opening up the annulus of Zinn. These procedures principally serve to decompress the optic canal and optic nerve swelling, and the resultant vascular compromise can cause secondary damage.

11. The glucocorticoid can be used to treat optic nerve injury, combined with a dehydrating agent, improved microcirculation drugs, neurotrophic drugs, and so on. Except those, erythropoietin may provide neuroprotection and support axonal growth. Glutamate is the major excitatory neurotransmitter in the eye that induces retinal ganglion cells apoptosis via binding to *N*-methyl-diacetylaspartate (NMDA) and kainate receptors. Glutamate inhibitors and NMDA receptor antagonists have been shown to promote retinal ganglion cell survival in rat models of optic nerve injury. Neurotrophic factors such as brain-derived neurotrophic factor are essential to retinal ganglion cell survival, and their absence is noted in optic nerve damage, for example, nonencephalitogenic myelin peptides.

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12 Ocular Perforating Injury

Hua Yan, Baoqun Yao, Chunjie Mao, Pingting Zhao, Fang Zheng, and Wei Zhang

Abstract

Ocular perforating injuries can cause significant vision loss and have worse prognosis than ocular penetrating injuries. However, it is difficult to distinguish one from another of these two kinds of open globe injuries in daily clinical practice. Comparing with ocular penetrating injuries, ocular perforating injuries are more challenging to manage due to the possible involvement of the whole eye and the inaccessible locations of the exit wound. Proper evaluation of the extent of the injury based on both trauma history taking and examinations and planning a surgical strategy is a key element for management of such patients. This chapter includes five cases with brief descriptions, illustrating figures and personal tips and tricks, aiming to provide a guide about diagnosis and management of ocular perforating injuries.

Keywords

Ocular perforating injury · Vitrectomy
Posterior exit wound · Foreign body

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12.1 Introduction

The ocular perforating injury (OPI) refers to an ocular injury with an entry and exit wound caused by a single object [1, 2]. It was also known as double-penetrating injury which had been replaced by perforating injury because the former term is not adequately specific as it may also be used to describe wounds caused by two foreign bodies that enter but do not exit the globe. The ocular perforating injury is usually caused by high-speed moving objects such as iron, steel, and glasses, and males were predominantly affected in relation to males' hyperactive behavior and work preferences [3, 4]. Comparing to other types of open global injuries, OPI has relatively lower incidence which was 2.45% and 2.93% in the epidemiology studies of open global injuries done in Egypt and Australia, respectively [5, 6]. It has been demonstrated that perforating injuries have significantly worse prognosis than blunt traumas, as any structure of the anterior segment to the posterior segment could be involved [7, 8]. For instance, corneal/scleral laceration, hyphema, traumatic cataract, vitreous hemorrhage, retinal detachment, epiretinal/subretinal hemorrhage, suprachoroidal hemorrhage, endophthalmitis, and proliferative vitreoretinopathy caused by the delayed effects of intraocular cellular proliferation could be found in OPI. The development of pars plana vitrectomy (PPV) has

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become the optimal treatment for such patients and prevented the injured eye being enucleated [9–11]. Proper specialized interventions of the lesions especially the exit wound are crucial to good visual prognosis [12].

12.2 Case #1: The Eye Hit by a Piece of "Steel"

12.2.1 Case Description

A 23-year-old male steelworker presented with a painful eye at the emergency room of Tianjin Medical University General Hospital 18 h after his right eye was hit by a piece of "steel." The right eye had no light perception. A 15-mm-long partial-thickness laceration was noticed on the upper eyelid of the right eye, penetrating through the muscular layer with still functional levator palpebrae superioris muscle. Conjunctiva was hyperemic and swollen. An irregular 8 mm full-thickness laceration was seen from 3 to 7 o'clock in the cornea. Other structure of the injured eye was blocked by dense hyphema. The intraocular pressure was low (T-2). The axial and coronal computed tomography (CT) scans of the orbit revealed a roundish high density foreign body located posterior to the eyeball (Fig. 12.1), which indicated ocular perforation injury. Surgical repair of the cornea and upper eyelid was arranged immediately after all the ocular examinations were done. One day after the surgery, the patient gained light perception vision. Ten days after surgery, the injured eye reached a relatively stable condition with a diagnosis of traumatic cataract, traumatic hyphema, traumatic vitreous hemorrhage, proliferative vitreoretinopathy, and intraorbital foreign body caused by the ocular perforating injury based on slit lamp examination (Fig. 12.2), B ultrasound (Fig. 12.3), and CT (Fig. 12.4). For further treatment of this eye, the

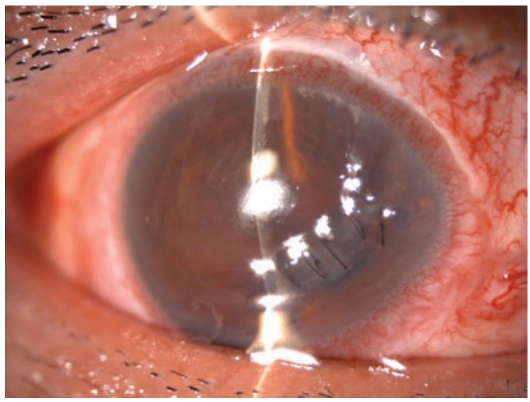

Fig. 12.2 The slit lamp examination of the right eye 10 days after the primary repairing surgery showing conjunctival hyperemia, the suture of the entry wound on the swollen cornea, hyphema, and traumatic cataract

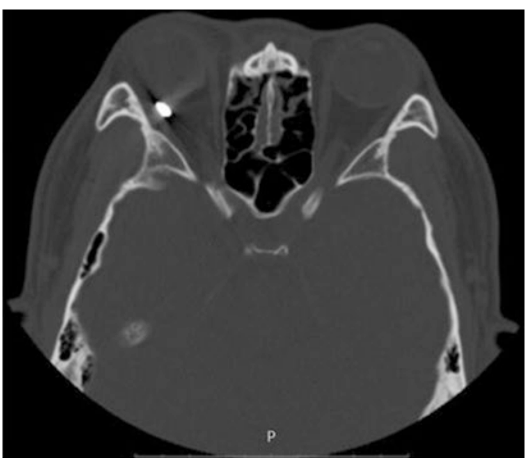

Fig. 12.1 The CT scan acquired 18 h after trauma showing the roundish metal foreign body located just behind the posterior wall of the eye with air surrounded and the irregular shape of the eyeball

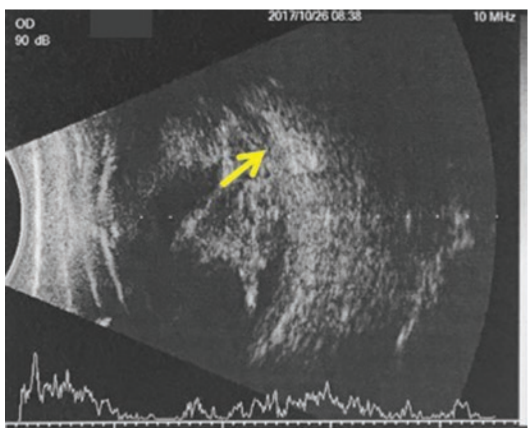

Fig. 12.3 The B-scan ultrasounds of the right eye acquired 10 days after the primary surgery which show incarceration of substance with irregular shape and strong echo around the possible exit wound

lensectomy-vitrectomy combined with silicone oil injection was performed under general anesthesia. During the surgery, the exit wound was observed located next to the fovea superior temporally (Fig. 12.5). One day after the lensectomy-vitrectomy, the patient gained counting finger vision at the temporal visual field of the right eye. With the cornea edema (Fig. 12.6) and epiretinal and subretinal hemorrhage resolving gradually, the fundus and healed wound were visualized 8 days after vitrectomy (Fig. 12.7). Three months after vitrectomy, the patient gained the best corrected visual acuity (BCVA) as 0.1 and intraocular pressure (IOP) as 17 mmHg. The exit wound was healed

Fig. 12.4 The CT scan taken 10 days after the primary surgery showing the metal foreign body still located posteriorly from the eyeball with the resorption of the air around it and no infection sign was observed

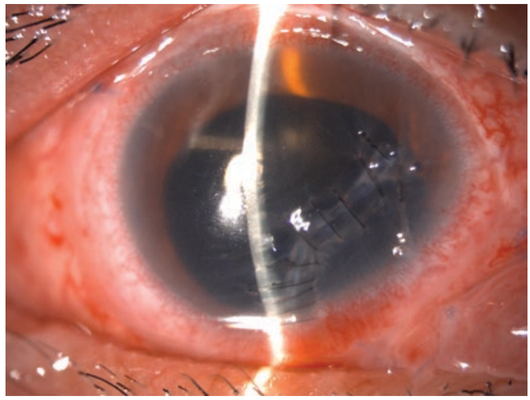

Fig. 12.6 The slit lamp examination of the right eye 8 days after the vitrectomy showing conjunctival hyperemia, the suture of the entry wound on the less swollen cornea, clear anterior chamber with a normal depth, dilated pupil, and aphakia

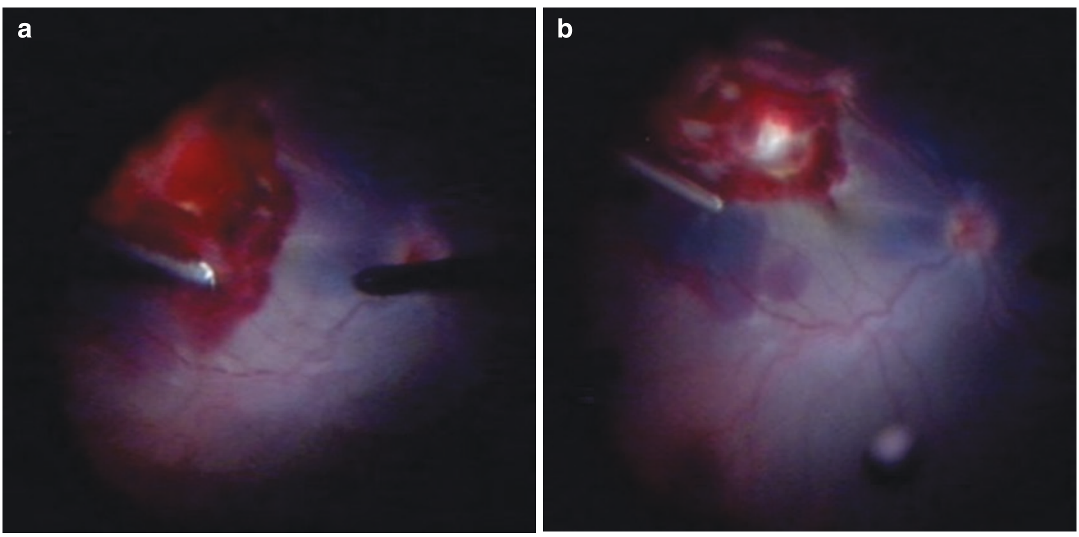

Fig. 12.5 The screenshot of the right eye's fundus during vitrectomy. (**a**) The exit wound involved the superior temporal part of the macula and was covered by hemorrhage. (**b**) After removing part of the blood around the wound, it was found that the wound hardly spared the fovea, and the subretinal hemorrhage can be noted inferior to the wound. The wound was like a volcano: the base was the healed scleral exit by fibrosis tissue, and crater was damaged retina and choroid tissue with coagulated blood

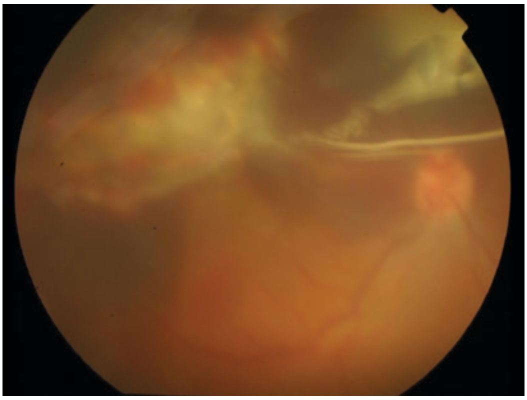

Fig. 12.7 The color fundus image of the right eye 8 days after vitrectomy showing the fibrosis tissue surrounding the wound and subretinal hemorrhage

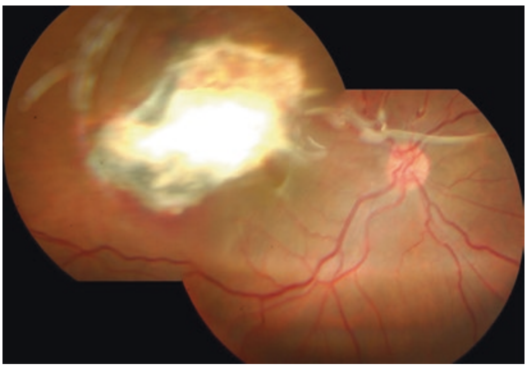

Fig. 12.8 The color fundus image of the right eye 3 months after vitrectomy showing the resolved subretinal hemorrhage and scar forming at the posterior wound with pigment changes and attached retina surrounded well with the scar tissue, and no retinal detachment was noticed (Fig. 12.8). Five months after vitrectomy, the eye still remained stable with the BCVA as 0.1, IOP as 16 mmHg, and retina surrounding the exit wound well attached (Fig. 12.9).

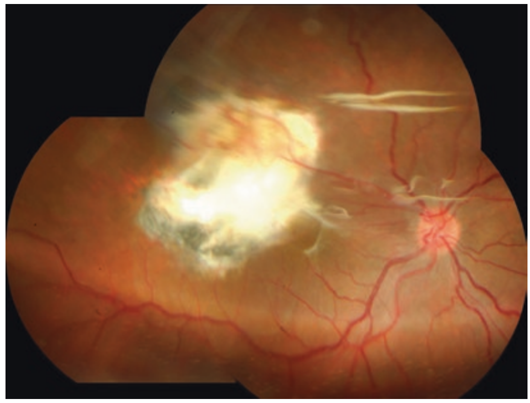

Fig. 12.9 The color fundus image of the right eye 5 months after vitrectomy showing scar at the posterior wound with pigment changes and attached retina surrounding the wound

12.2.2 Tips and Pearls

The eye was hit by a piece of metal when the patient was peening the steel. According to eye examinations and CT scans, the metal penetrated the eye through the cornea and located in the orbit, which indicated the metal was with a certain amount of hardness and high speed. The streak artifacts of the metal on CT scans suggested its magnetic property. As the streak artifacts of the foreign body blocking part of the posterior wall, there should be a suspicion that the foreign body may insert the wall. Comprehensive preparation needs to be done before the surgery for moving the foreign body.

The posterior exit wound is usually difficult to be located and sutured. PPV should be performed within 2 weeks to remove vitreous hemorrhage and release the traction caused by fibrosis proliferation on the retina, especially the retina around the exit wound, as well as locate and check up the exit wound. Laser photocoagulation should be done to seal the tear of the retina if the tear occured away from the macula. If the wound is in the macula and there is no retinal detachment around the wound, laser photocoagulation is not recommended.

The exit wound healing not only includes the healing of the retina and choroid but also involves the healing of the sclera by fibrosis formation. Generally speaking, the exit wound is often found to be closed up a few days after primary surgery, and managing the retinal damage becomes the major issue. In this case, the posterior exit of the eye ball had already been sealed by scar tissue at the time of vitrectomy. So the surgeon decided to treat the wound without further laser treatment after vitrectomy as there was no retinal detachment noted around

the exit wound. If the posterior wound wasn't closed, filling the open one with a same size Tenon's capsule or absorbable gelatin sponge should be an option. Regarding the removal of the intraorbital foreign body, posteriorly located inorganic intraorbital foreign body should be left alone, unless they are causing significant orbital complications such as neurological compromise, mechanical restriction of ocular movements, acute or chronic inflammation, or infection [13]. The objects causing ocular perforating injury are usually metal with high hardness and relatively low magnetism, which are usually well-tolerated and seldom lead to orbital siderosis [14]. However, long-term regular electroretinography evaluation is recommended for monitoring possible retinal toxicity from the foreign bodies [15]. It's known that the oxidative damage of iron on the surrounding tissue can be enhanced by ascorbic acid through increasing the production of hydroxyl radicals and lipid alkoxyl radicals [16, 17], the fact of orbital tissue is lack of ascorbic acid which leads to less possibility of such damage. What's more, the foreign bodies would be covered by fibrosis tissue gradually and be less active as time passes by. And there is no evidence of the foreign body causing infection, affecting eye movement or migrating toward critical orbital structure in this case. So the foreign body wasn't removed during the surgery, and close follow-up was indicated to the patient.

12.3 Case #2: The Eye Hit by an "Iron" Nail

12.3.1 Case Description

A 39-year-old man presented at the emergency room with the right eye hit by an "iron" nail 8 h ago. The visual acuity of this eye was hand motion (HM)/30 cm which couldn't be corrected. The intraocular pressure (IOP) was 9.4 mmHg. The slit lamp examination revealed a central full-thickness edematous corneal laceration, relatively shallow anterior chamber, cloudy aqueous humor, round pupil with the diameter of 3 mm, and opacified lens cortex with a partial outflow of it through the ruptured anterior capsule (Fig. 12.10). Orbital computerized tomography (CT) showed perforating global injury of the right eye with uncompleted lens structure and hyperreflective intraocular foreign body (IOFB) penetrating through the posterior global wall (Fig. 12.11). B-scan ultrasonography showed a high echo in the vitreous body which was suspected to be the IOFB (Fig. 12.12). A combined surgery was performed immediately including debridement and suture of the cornea, cataract extraction, pars plana vitrectomy, IOFB extraction, fluid-air exchange, intraocular laser photocoagulation, and C2F6 gas tamponade. It turned out that the IOFB was a "steel" nail with about 16 mm long (Fig. 12.13). The IOP was low for 5 days after surgery which was probably caused by the loss of C2F6 gas through the unclosed posterior wound. The OCT was acquired for a better understanding of the exit wound and demonstrated a full thickness of the retina and choroid hole at the site of the wound as well as deficiency of outer nuclear layer and irregularity of IS/OS (ellipsoid zone) under the fovea (Fig. 12.14a, b). Another surgery of fluid-air exchange was performed for raising the IOP at the 6th day after the primary surgery. Four days after the

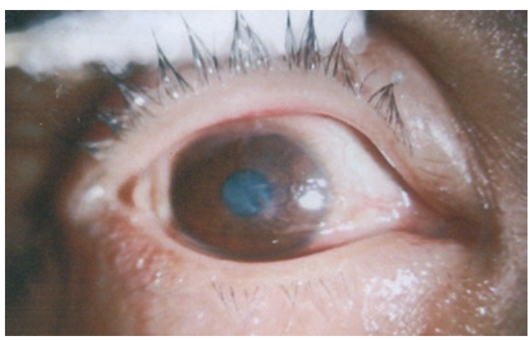

Fig. 12.10 The slit lamp image showing a full-thickness edematous laceration at the center of the cornea, shallow anterior chamber, cloudy aqueous humor, round pupil with the diameter of 3 mm, and opacified lens cortex with a partial outflow of it through the ruptured anterior capsule

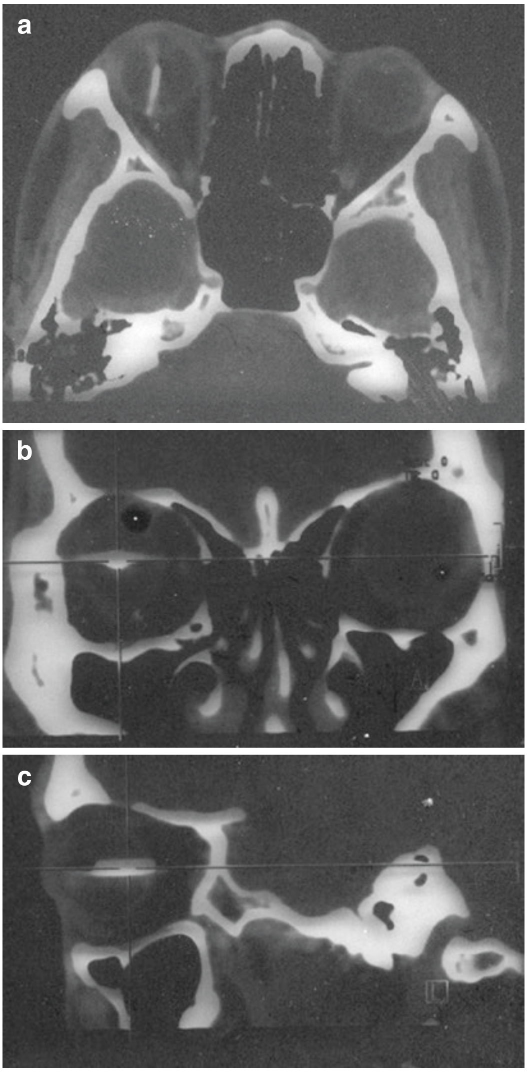

Fig. 12.11 Orbital CT scans of the patient before surgery showing the intraocular foreign body (IOFB) from different angle of the view. (**a**) The axial CT scan showing destroyed lens and hyperreflective IOFB in the vitreous body and penetrating through the posterior global wall. (**b**) The coronal CT scan showing the cross section of the foreign body. (**c**) The sagittal CT scan showing the IOFB embedded in the posterior global wall

secondary surgery, the IOP rose to 19.8 mmHg, but the visual acuity was still HM/30 cm partially due to the gas/fluid interference. The eye examination revealed congestion of the bulbar conjunctiva, well-healed cornea wound, aqueous flare (+), unabsorbed air bubble in the anterior chamber, irregular dilated pupil (7 mm in

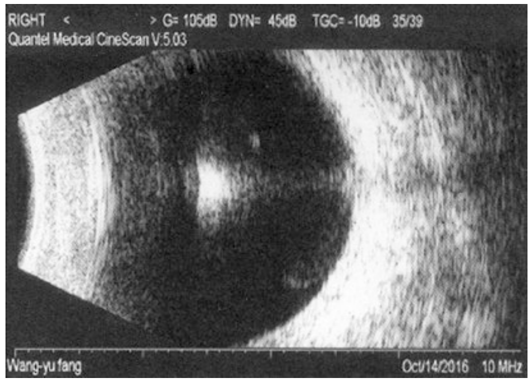

Fig. 12.12 Ultrasonography of the injured eye demonstrating chaotic vitreous body and a high echo substance which was suspected to be the intraocular foreign body

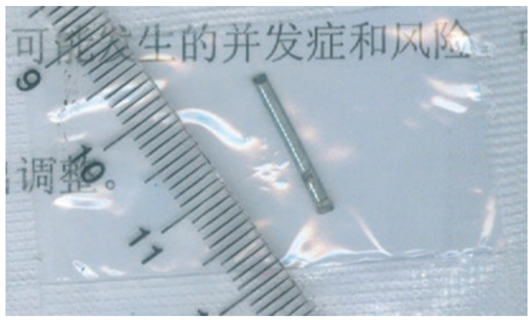

Fig. 12.13 The removed intraocular foreign body during the primary combined vitrectomy surgery was a "steel" nail with length about 16 mm

diameter), lack of the lens (Fig. 12.15), clear vitreous cavity with gas filling 4/5 of the space, and attached retina. Three months after the secondary surgery, the best corrected visual acuity (BCVA) was 0.02, and IOP was 9.6 mmHg. Mildly congested conjunctiva, corneal scar, normal depth anterior chamber, clear aqueous fluid, irregular pupil with the diameter of 7 mm, and aphakia were noted during the slit lamp examination (Fig. 12.16). The retina remained flat with laser spots (Fig. 12.17).

12.3.2 Tips and Pearls

Compared with high magnetic IOFB, the IOFB in this case was easier to locate as there were no radical streak artifacts on the orbital CT images.

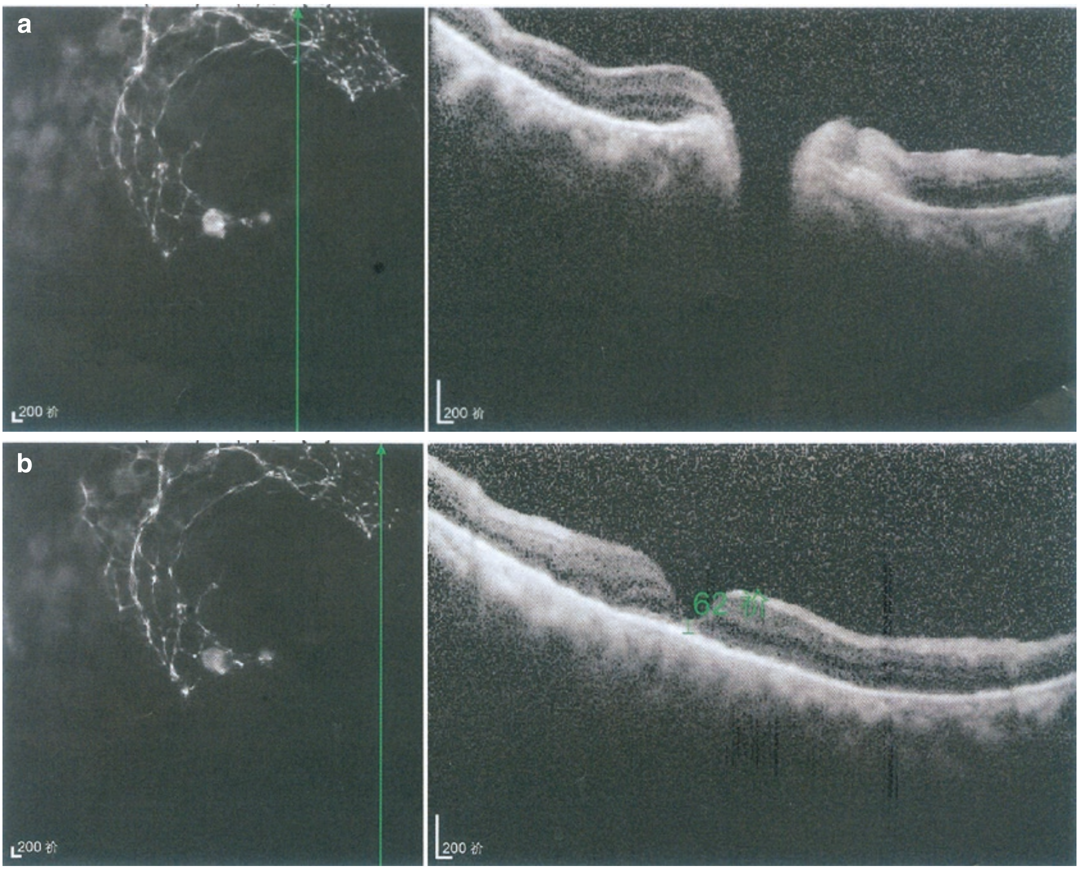

Fig. 12.14 The OCT scans taken at the 5 days after the primary operation. (**a**) The OCT B-scan through the site of the exit wound showing a full thickness of the retina and choroid hole. (**b**) The OCT B-scan through the fovea showing the deficiency of outer nuclear layer under fovea and irregularity of IS/OS (ellipsoid zone)

Fig. 12.15 The slit lamp photography taken at 10 days after the primary surgery showing congested bulbar conjunctiva, well-healed corneal wound with mild edema, aqueous flare (+), unresolved air bubble, irregular dilated pupil with the diameter of 7 mm, and lack of lens

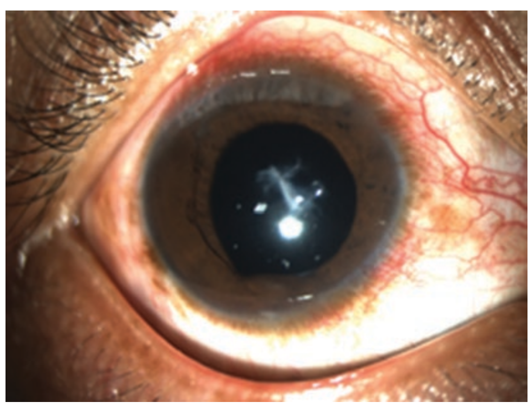

Fig. 12.16 The slit lamp image acquired at 3 months after the primary surgery showing slightly congested conjunctiva, corneal scar, normal depth anterior chamber, clear aqueous fluid, irregular pupil with the diameter of 7 mm, and aphakia

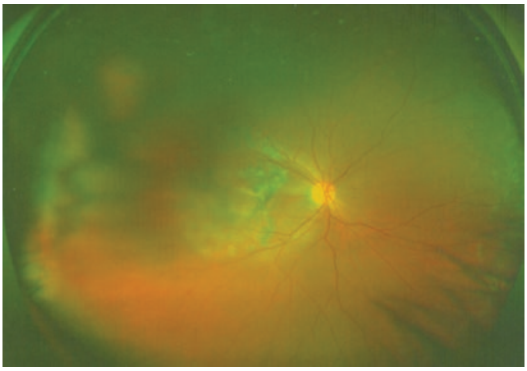

Fig. 12.17 The wide-field color fundus image taken at 3 months after the primary surgery showing flat retina with laser spots

Since the IOFB was erected in the vitreous body, it is reasonable to judge the foreign body penetrating through the posterior eyewall and generating a full-thickness hole which helps supporting the IOFB stay vertical to the eyewall. Hence, a detailed strategy for removing the large foreign body with as little damage as possible should be designed carefully before the surgery.

Vitrectomy has been proved to be of a high efficacy for the treatment of perforating ocular injuries complicating with foreign bodies located at the posterior global wall, with a low incidence of postoperative complications [18]. The final visual outcome depends on the macular or the optic nerve involvement and the final retinal stability [11, 19]. Since the IOFB in this patient penetrated the retina close to the fovea at the temporal side and the OCT confirmed the damage of the trauma to the fovea, the final best corrected visual acuity was 0.02. The timing of IOFB removal was still controversial. Guevara-Villarreal DA and Rodríguez-Valdés PJ advise to perform IOFB extraction immediately when endoophthalmitis suspected; otherwise it can be delayed for a few days until corneal edema resolves and allows a better visualization during vitrectomy, intraocular inflammation is controlled, and suprachoroidal hemorrhage liquefies and thus can be drained if necessary. These processes usually take 3–14 days [20]. Appropriate therapeutic regimen should be selected in terms of different situations. In the current case, vitrectomy was performed for removing the IOFB, and the key point of the surgery was taking out the IOFB with less further damage. A new incision at the limbus with a slightly wider than the diameter of the IOFB was made for removing the foreign body, which allows no second trauma to the full-thickness laceration at the center of the cornea. Gently and slowly pulling the foreign body out of the posterior eyewall is essential to keep a stable IOP and avoid hemorrhage. If the IOFB was surrounded by fibrosis and/or the retina, complete separation needs to be done before removing the IOFB for preventing iatrogenic retinal detachment.

No specific management was performed to the exit wound in this case given that the size of the wound was small based on surgeon's observation and the IOP was maintained at a stable level during the surgery. Filling the eyeball with C2F6 which is a kind of inert gas is a good option to maintain the IOP after surgery and keep the wound dry. Although some gas may leak from the eye, the rest gas can still stabilize the pressure by expansion. Careful monitoring of the IOP should be indicated since the unclosed posterior wound could possibly result in low IOP which may cause choroidal detachment and retinal detachment. Once IOP is low, another fluid-air exchange needs to be performed for maintaining the IOP in a normal range.

12.4 Case #3: An Ocular Penetrating Injury?

12.4.1 Case Description

A 16-year-old man without any ocular disease history complained of sudden vision loss and severe sharp pain in the right eye approximately 2 h after foreign body (FB) injured the eye when he was striking the metal with a hammer. The visual acuity of this eye was 0.03. The slit lamp examination showed moderate conjunctival hyperemia, mild chemosis, a full-thickness self-sealed 2.5-mm-long corneal laceration inferior to the pupil, +1 flare, and shallow anterior chamber inferiorly (Fig. 12.18a). The penetrating

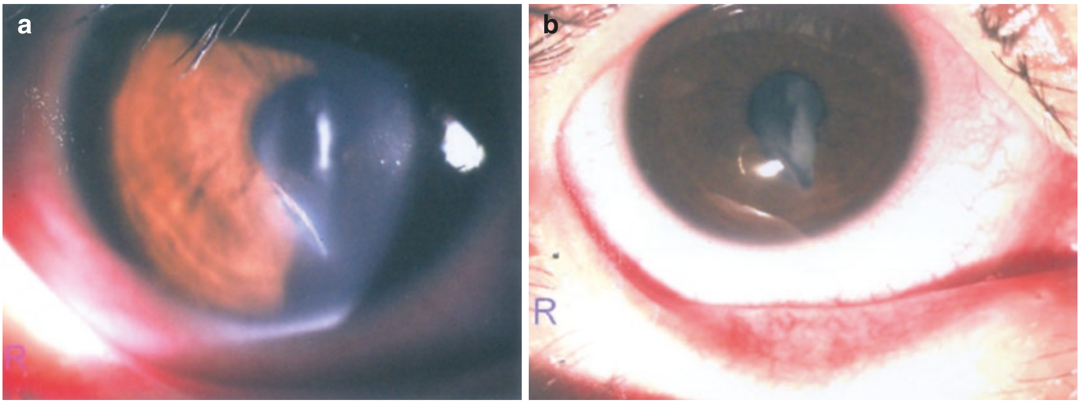

Fig. 12.18 The slit lamp images of the patients. (**a**) Conjunctival hyperemia, chemosis, and the full-thickness cornea wound below the center of the cornea. (**b**) The iris laceration at 5 o'clock position and the traumatic cataract caused by the foreign body

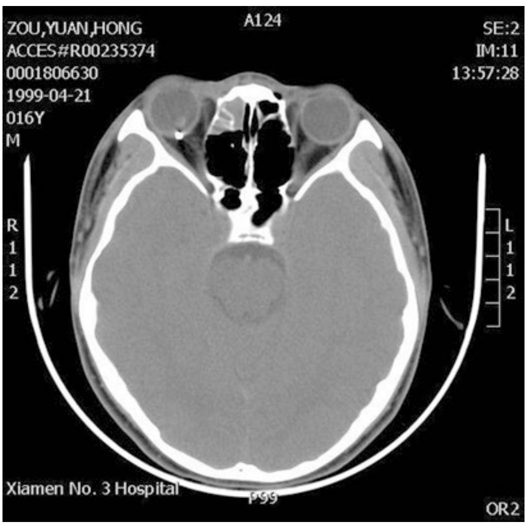

Fig. 12.19 The CT scan showing the metallic foreign body just located at the posterior global wall

injury of the iris at 5 o'clock position and dense traumatic cataract with disruption of anterior lens capsule were noticed as well (Fig. 12.18b). No vitreous body was observed in the anterior chamber. Vitreous and fundus could not be visualized due to media opacification. The axial computerized tomography (CT) scan of the orbit revealed a hyperdense FB located in the posterior global wall of the right eye suggesting ocular wall FB and a media-dense substance anterior to the FB which might be the vitreous hemorrhage (Fig. 12.19). B-scan ultrasonography of the right eye showed vitreous hemorrhage and strong echoes with posterior acoustic shadow which cloud be the FB (Fig. 12.20). The primary diagnosis of an ocular penetrating injury, corneal laceration, traumatic cataract, vitreous hemorrhage, and a metallic intraocular FB was made based on all the examinations. Corneal laceration repair, pars plana vitrectomy, lensectomy, and removal of the metallic intraocular FB were arranged. However, the metallic FB was found inserted into the ocular wall and generated an exit wound, instead of staying in the vitreous cavity. The posterior wound was about 1.5PD and located below the inferior arcade. Ocular perforating injury was made based on the surgical finding. Intravitreal tamponades of gas and laser photocoagulation was used to close the wound track. A 0.5 × 1 × 3 mm metal plate was extracted by magnet behind the eyeball (Fig. 12.21). The retina remained attached at 3 months after the gas was complete absorbed (Fig. 12.22). Four months later, the patient underwent intraocular lens implantation (Fig. 12.23), and the best corrected visual acuity was 0.3.

12.4.2 Tips and Pearls

In this case, the patient was diagnosed with an ocular penetrating injury, corneal laceration,

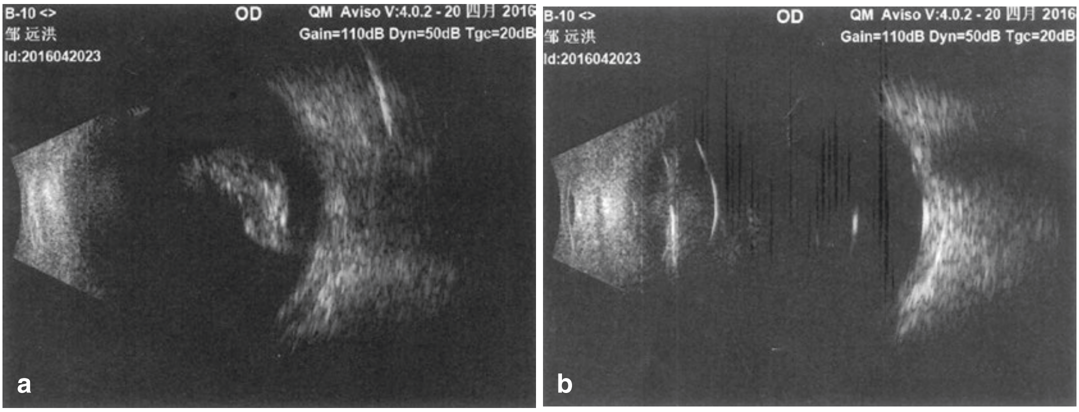

Fig. 12.20 B-scan ultrasonography of the injured eye. (**a**) The vitreous hemorrhage was manifested as moving internal echoes in posterior segment. (**b**) The possible foreign body located at the posterior eyewall

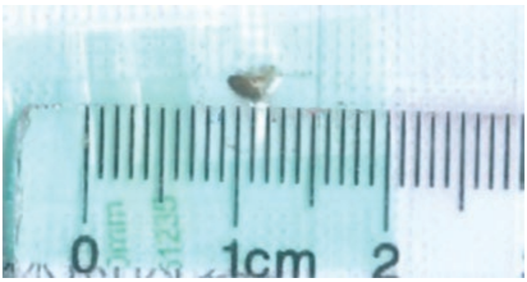

Fig. 12.21 The 0.5 × 1 × 3 mm metal plate was extracted by magnet behind the eyeball during the surgery

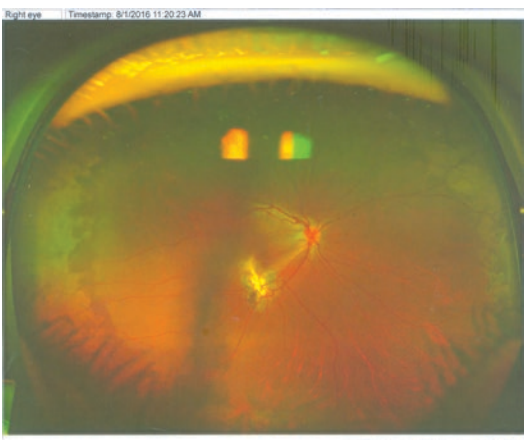

Fig. 12.22 The wide-field color fundus photograph showing the retina scar around the exit wound inferior to the macula after C3F8 gas completely absorbed 3 months after vitrectomy

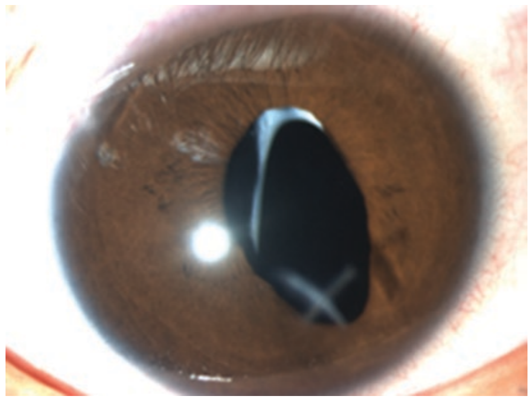

Fig. 12.23 The slit lamp examination of the right eye 4 months after vitrectomy showing transplant cornea, clear aqueous fluid, irregular pupil, and well-centered IOL

traumatic cataract, vitreous hemorrhage, and a metallic intraocular FB in the emergency room, because a well-defined hyperdense FB was just located in the eyewall and vitreous hemorrhage was seen in the posterior segment of the right eye according to the orbital CT scans and B-scan ultrasonography and the shape of the eyeball was regular, which also suggested unbroken posterior eyewall. However, the FB was found inserted into the eyewall during the surgery, and wounds on the retina, choroid, and sclera caused by the FB were confirmed when the FB was extracted by magnet. After the FB were removed, the intraocular pressure was reduced, and the conjunctival edema was observed, which was mainly due to the slight leakage of intraocular infusion fluid through the full-thickness wound of the posterior eyeball. Finally the final diagnosis of ocular perforating injury with intraorbital FB was made, instead of ocular penetrating injury with intraocular FB.

Coexistence of ocular surface and intraocular damages often limit intraoperative visualization, and a perforating through-and-through injury should be suspected if the IOFB cannot be identified during vitrectomy [8]. The surgeon found the FB was located within the "hole" of the ocular wall. The retinal lesion around the wound was "sealed" by laser photocoagulation before the FB was taken out by magnet. This preparatory work avoids secondary damage to the surrounding retina caused by removing the FB, such as retinal detachment. When the FB was taken out, the exit wound may lead to perfusion leakage, ocular hypotension, orbital pressure increase, and choroidal detachment. It was reported that a same size Tenon's capsule, absorbable gelatin sponge, or sodium hyaluronate could be used to seal the wound, but the efficiency is still controversial. The posterior pole wound in this case was small and half sealed by the dense orbital tissue, so the surgeon decided not to close the wound of posterior eyewall. C3F8 gas was used to tamponade the vitreous cavity, and the surface tension between liquid and gas could help in wound healing. C3F8 is a better material to maintain the stability of intraocular pressure than liquid. Because liquid can leak into the orbital cavity through the wound, and C3F8 was expanding gas, even if part of gas leaked, the expansion of the subsequent volume could still compensate to stabilize the intraocular pressure. The key step of using gas to heal the wound was closing the three-channel sclerotomy as soon as possible when the gas-fluid exchange is completed.

The poorest prognostic associations of FBs quoted in the literature are endophthalmitis, retinal detachment, and proliferative vitreoretinopathy (PVR). The delayed surgery until the media clear up decreases the chances for vision recovery, as PVR may develop within a few days, with irreversible damage to the retina. On the other hand, continuing surgery under poor visualization conditions carries the risk of inducing iatrogenic lesions that worsens the condition. For these reasons, FBs require prompt evaluation and management (in this case, the FB was taken out in the one-stage operation), considering they may quickly lead to vision-threatening complications [21–23].

12.5 Case #4: The Eye Hit by a Sheet Metal

12.5.1 Case Description

A 60-year-old man presented to our emergency clinic on 10 January 2017, with the chief complaint of trauma to his right eye by a foreign body occurring approximately 1 h ago. The right eye had no light perception with the T-1 intraocular pressure. The eyeball was found penetrated at the inferior nasal sclera. The cornea had light edema, the anterior chamber was bloody and cloudy, the diameter of the pupil was about 3 mm, and the pupillary light reflex was absent. The lens, vitreous body, and fundus were not clearly visualized (Fig. 12.24). Orbital X-ray and computerized tomography (CT) showed that the right eye had perforating injury, with high-density foreign body in the ball with the size about 9.68 × 5.69 mm. It showed that a small part of foreign body was located in the ball, and a large part of it was located outside the ball. The foreign body had streak artifacts, considered as the magnetic foreign body. Before the operation, vitreous sample was taken for bacterial culture examination but without any bacteria and mycelia (Fig. 12.25).

Scleral debridement and suture, intraocular foreign body removal, and anterior chamber irrigation were performed in the right eye. A metallic

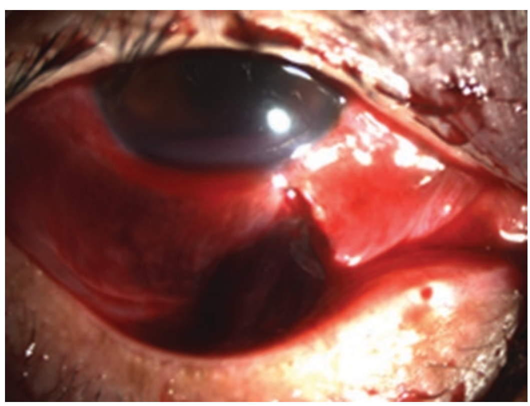

Fig. 12.24 The appearance of the injured eye before surgery. The eyeball was found penetrated at the inferior nasal sclera

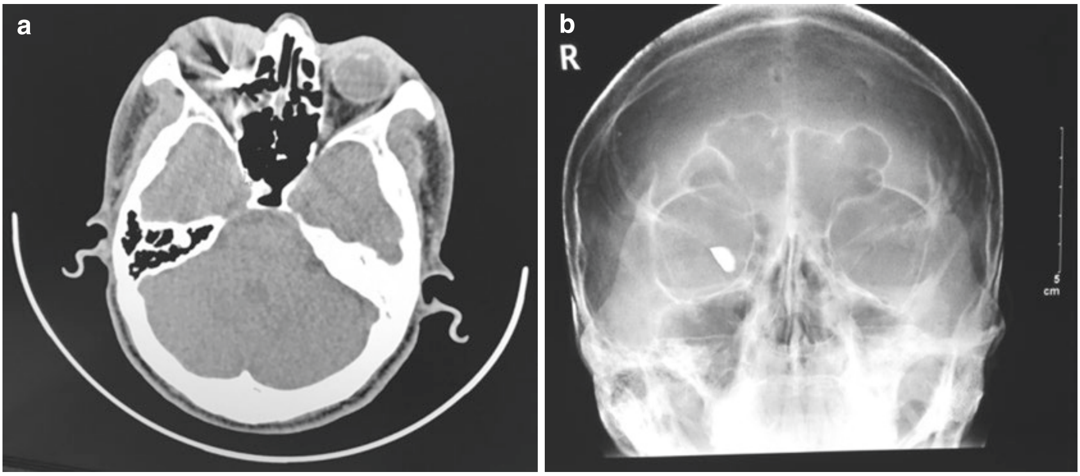

Fig. 12.25 Orbital CT (**a**) and X-ray (**b**) showing the right eye has perforating injury, with high-density foreign body in the ball, about 9.68 × 5.69 mm

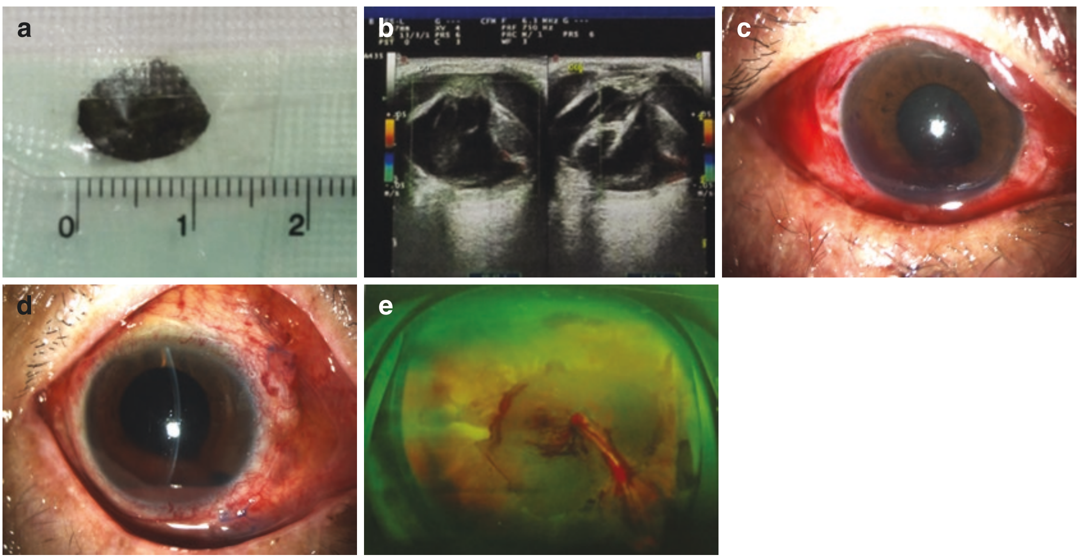

Fig. 12.26 (**a**) The removed metallic foreign body (size 12 × 9 × 3 mm). (**b**) Ocular ultrasound showing a V-shape membrane attached to the optic nerve head, indicative of a total retinal detachment and choroidal detachment. (**c**) The appearance of the eye after scleral debridement and suture and after the intraocular foreign body was successfully removed. (**d**) After a vitrectomy combined with silicone oil filling, a good anatomical result was achieved. (**e**) The pole part of the retina was missing, the surrounding residual retina was visible, and scleral laceration was visible

foreign body (size 12 × 9 × 3 mm) was removed (Fig. 12.26a) in the primary surgery (suture and debridement of sclera combined with removal of intraocular foreign body). After the surgery, ocular ultrasound showed a V-shape membrane attached to the optic nerve head, indicative of a total retinal detachment and choroidal detachment (Fig. 12.26b). And an anatomical healing of ocular surface was achieved after the primary surgery (Fig. 12.27c). A vitrectomy combined with silicone oil filling was performed at 8 days after the primary surgery, and the corrected visual acuity indicated no light perception in the right eye, with the intraocular pressure being 13.8 mmHg.

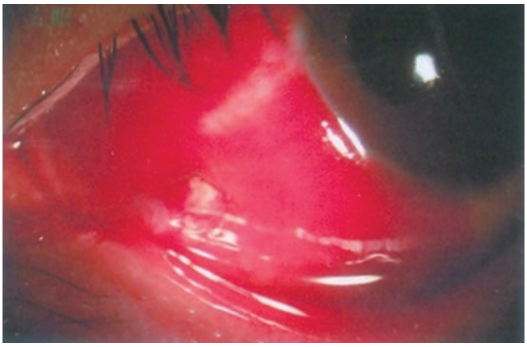

Fig. 12.27 The slit lamp image of the right eye showing subconjunctival hemorrhage with a conjunctival laceration

Three days after vitrectomy surgery, it showed conjunctival congestion and corneal light edema, hyphema with 1 mm height, the absence of lens, and intravitreal silicone oil filling. The part of the retina was missing, the surrounding residual retina was visible, and scleral scar was visible (Fig. 12.26d, e).

12.5.2 Tips and Pearls

Penetrating and perforating injuries involving the posterior segment of the globe often result in severe visual loss and carry a worse prognosis than blunt traumas, especially in young adults or children and if associated with an intraocular foreign body [8, 24]. In this case, the diagnosis of perforating injury was unclear due to the following factors: (1) The eyeball was found penetrated at the sclera. The anterior chamber was bloody and cloudy, and the vitreous body and the fundus were also not clear. Therefore, it was difficult to detect the injured site in the posterior part of the eyeball. (2) Orbital X-ray and CT showed the right eye had perforating injury, with high-density foreign body in the ball. However, it was difficult to detect the exact location of the high-density foreign body only based on CT, due to the radical streak artifact of such foreign body. We considered that the small part of foreign body was located in the ball and a large part of it was located outside the ball. We performed scleral debridement and suture, intraocular foreign body removal, and anterior chamber irrigation. A metallic foreign body (size 12 × 9 × 3 mm) was removed, and posterior scleral wound was found. It was confirmed the diagnosis of perforating injury.

In this case, vitrectomy was performed at 8 days after primary surgery, as we thought that time allows better recovery of the wound and development of spontaneous PVD, which makes vitrectomy safer and more likely to be completed [25]. In this case, a 23-gauge micro-vitreoretinal blade was used for the three sclerotomies at 3.5 mm from limbus. Vitrectomy was completed from the posterior to the anterior part as much as possible to clear the hemorrhage and hyperplasia of the posterior injury site. Laser was applied over the equatorial area and around any retinal tear and especially around the injury site. After air-PFC exchange, silicone oil was injected manually through the upper sclerotomy, considering that it was hard for the elderly to hold the prone position for a long time. In this case, it is not recommended to remove intraocular foreign body by primary surgery. The reason is that it could tear posterior scleral wound and increase the chance of bleeding, which is hard for the healing of posterior scleral wound. It is recommended to remove intraocular foreign body by vitrectomy.

12.6 Case #5: The Eye Hit by a Piece of Steel and Intraorbital Foreign Body

12.6.1 Case Description

A 24-year-old Chinese man that got shot on the left eye by steel presented in the emergency room with red painful eye and blurred vision. On the initial examinations, best-corrected visual acuity (BCVA) was 0.3. Slit lamp examination revealed subconjunctival hemorrhage with a conjunctival laceration about 2 mm length on the nasal side, but no foreign body was seen (Fig. 12.27). The anterior chamber was at normal depth with hyphema (Fig. 12.28). Hemorrhagic vitreous opacity and preretinal hemorrhage with retinal edema were seen on the nasal side (Fig. 12.29). Hyphema

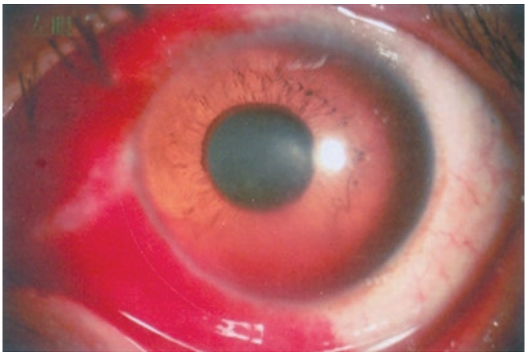

Fig. 12.28 The slit lamp image of the right eye showing hyphema

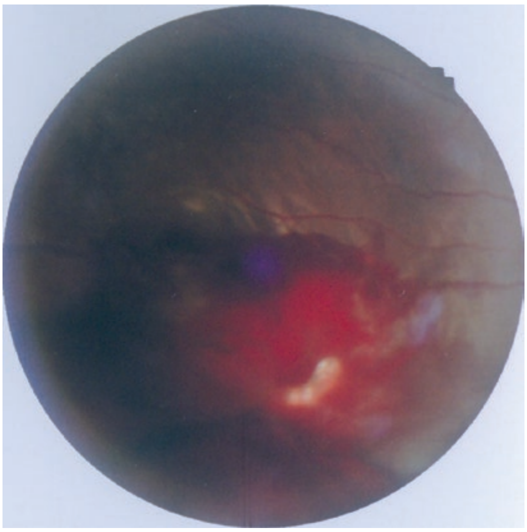

Fig. 12.29 Fundus image taken in the emergency room showing hemorrhagic vitreous opacity and retinal edema, with preretinal and subretinal hemorrhage and retinal laceration on the nasal side

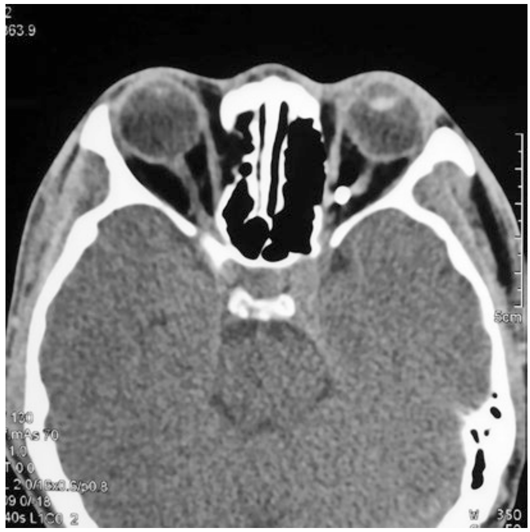

Fig. 12.30 Preoperative axial computed tomography (CT) scan revealing a metallic foreign body located in deep orbit muscles cones

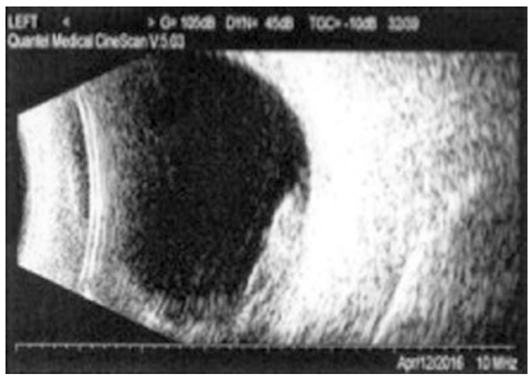

Fig. 12.31 Ocular ultrasonography B-scan demonstrating an abnormal echo on the inferior nasal side of the eyeball at the fifth day after the primary surgery

blocked the visualization of other structures of the eye. The intraocular pressure was 6.4 mmHg. Preoperative axial and coronal computed tomography (CT) revealed a metallic foreign body in deep orbit muscles cones (Fig. 12.30), which indicates ocular perforation injury. Scleral entrance wound and conjunctiva laceration were repaired with intravitreous antibiotic injection at primary repair. Ocular ultrasonography demonstrated an abnormal echo on the inferior nasal side of the eyeball at the fifth day after primary repair (Fig. 12.31). And fundus examination showed retinal laceration with periphery retinal detachment inferior nasally, with choroidal defect and closed scleral wound (Fig. 12.32). Eight days after primary repair, vitrectomy was performed with air-fluid exchange, laser photocoagulation, and silicone oil filling. The postoperative BCVA was 0.6 and intraocular pressure was 19.1 mmHg. The fundus examination showed laser points around the inferior nasal exit wound, with damaged choroid and uncovered sclera (Fig. 12.33). Two weeks later, orbital surgery was performed to search and remove the foreign body by open-

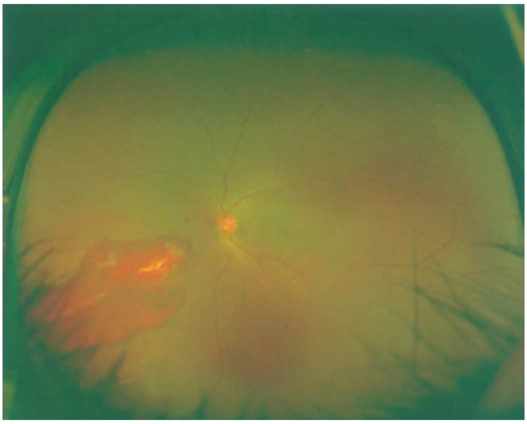

Fig. 12.32 Color fundus image showing retinal laceration with periphery retinal detachment on the inferior nasal side, with choroidal defect and closed scleral wound at the fifth day after the primary surgery

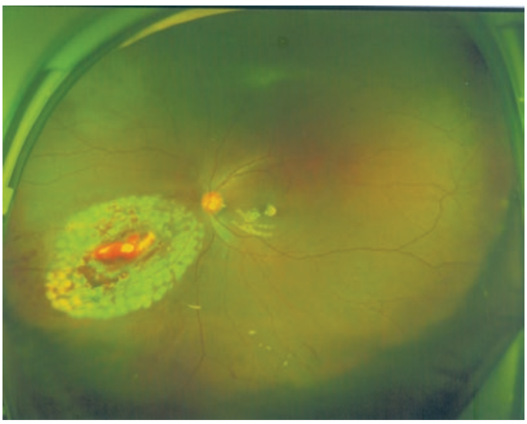

Fig. 12.33 Color fundus image showing laser points around the inferior nasal exit wound, with damaged choroid and uncovered sclera after vitrectomy

ing lateral orbital wall, but unfortunately, the steel shot was not found. Postoperative examination showed a normal eye position, with normal movement in 1 month after orbital surgery (Fig. 12.34).

12.6.2 Tips and Pearls

From the primary examinations, the conjunctival and scleral laceration had a distance to the cornea, and injury was not found in the corresponding iris, so the foreign body was more easily to enter posterior part of the eye without resistance

Fig. 12.34 Postoperative photography showing the normal eye position

from the iris. The roundish high-density foreign body with no radical streak artifacts located in deep orbit muscles cones on CT scans indicated the possibility of ocular perforation injury. Lower intraocular pressure (7 mmHg) was another evidence for the existence of posterior wound, as the anterior wound was self-closed well. However, the posterior wound was not visualized due to the blockage of vitreous, preretinal, and subretinal hemorrhage. The diagnosis of ocular perforation injury was confirmed by the fundus examination at the fifth day after primary repair, which revealed retinal laceration with periphery retinal detachment, choroidal defect, and closed scleral wound. The entrance and exit wounds were necessary for diagnosis with perforation injury [13]. If the fundus couldn't be examined clearly due to vitreous or retinal hemorrhage, proper observation time should be given for hemorrhage absorption. If necessary, vitrectomy could be performed for confirming the diagnosis and treatment.

Considering retinal laceration with periphery retinal detachment, vitrectomy was performed in this patient combined with local laser photocoagulation and silicone oil filling. Also vitrectomy prevented the eye from developing traumatic proliferative vitreoretinopathy and severe tractional retinal detachment. However, keeping prone position is also feasible for young patients with local retinal detachment instead of vitrectomy, because young people's vitreous is not completely liquefied and keeping prone position can help in pushing the detached retina back to the wall. Also, the growth factors from the retinal hemorrhage caused by the injury are beneficial to healing in this patient. So for such patients, close observation can be the first

choice, and surgery needs to be performed, only if retinal detachment progresses.

Posteriorly located inorganic infraorbital foreign body should be left alone, unless they affect eyesight or ocular movement or causing acute or chronic inflammation or infection [13]. The objects causing ocular perforating injury are usually metal with high hardness and relatively low magnetism, which are usually well-tolerated and seldom lead to orbital siderosis [14]. It's known that the oxidative damage of iron on the surrounding tissue can be enhanced by ascorbic acid by increasing the production of hydroxyl radicals and lipid alkoxyl radicals [16, 17]. The fact with orbital tissue is that the lack of ascorbic acid leads to less possibility of such damage. As the foreign body was little in size and maybe got covered by fibrosis tissue gradually, it was difficult to locate and remove it even by opening lateral orbital wall in this patient.

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13 Ruptured Globe

Zhijun Wang, Yujie Yan, Tong Zhao, Chuan Sun,
and You Chen

Abstract

Ruptured globe is an ophthalmologic emergency, leading to disrupted integrity of the outer membranes of the eye. Patients usually present with a history of ocular trauma; symptoms include pain and decreased vision. However, physical examination may be obvious or occult. B scanning and CT are important in diagnosis. Surgical managements include suturing of the globe and secondary vitrectomy. For eyes with low IOP, supplementary silicon oil injection may be applied to increase the IOP. For those eyes with NLP, conjunctival flap technique may help release pain and improve appearance.

Keywords

Ruptured globe · Clinical manifestation
Surgical management

13.1 Introduction

13.1.1 Definition and the Mechanism

Globe rupture is an ophthalmologic emergency secondary to blunt or penetrating trauma leading to disrupted integrity of the outer membranes of the eye. Blunt trauma is often caused by a hit directly on the eye by a blunt object, such as a ball, club, or a fist. Ruptures from blunt trauma are most common at the sites where the sclera is thinnest, at the insertions of the extraocular muscles, at the limbus, and at the site of previous intraocular surgery. Sharp trauma includes being forcefully poked by a sharp object, such as a knife, pencil, or scissors. Cornea and anterior sclera are more likely involved. Other causing factors include being stuck by a flying object such as a bullet and striking the face on a hard object [1–3].

13.1.2 Clinical Manifestation

The patient usually presents with a history of ocular trauma; symptoms include pain and decreased vision. Diplopia may be present due to extraocular muscle entrapment or dysfunction and trauma-associated cranial nerve palsy. At physical examination the globe rupture may be obvious or occult. Severe conjunctival hemorrhage, usually involving 360° of bulbar conjunctiva, typically indicates globe rupture. Other accompanying signs include irregular pupil, hyphema, lens injury, commotio retinae, vitreous hemorrhage, choroidal rupture, retinal tears and detachments, and traumatic optic neuropathy. A ruptured globe may present with

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both enophthalmos and exophthalmos, depending on the presence of an associated retrobulbar hemorrhage.

13.1.3 Ophthalmic Examination

Ordinary examinations include vision acuity, intraocular pressure, general examination of external eye, and silt lamp microscope. Examination should proceed systematically in both the injured and normal eye. It is critical to avoid putting pressure on a ruptured globe to prevent any potential extrusion of intraocular contents and to avoid further damage.

Severe visual loss which is often lower than "counting fingers" indicates complicated ocular rupture. Another strong evidence for ocular rupture is lowered intraocular pressure. For most ruptured eyes, however, the intraocular pressure cannot be measured successfully by noncontact tonometer, while Goldmann tonometer is also not suitable especially in cases complicated with evident intraocular tissue prolapse, which may induce further damages and increase the risk of endophthalmitis. Through examination of external eye and slit lamp, most damages of eyeballs and appendages of the eye could be found, such as lacerations of the eyelid, conjunctiva, cornea, and sclera, uveal prolapse, lens injury, vitreous extrusion, and other signs secondary to rupture which include hemorrhage, afferent pupillary defect, lens dislocation, retinal tear, etc. Some special situation should be paid particular attention. (1) The exposure of the eyeball could be quite difficult when it is tightly covered by extremely swelling eyelids, which implies severe ocular rupture. Holding the eyelids open forcibly is not reasonable and an immediate CT scan is necessary. (2) Thick and wide-range conjunctival hemorrhage should be alerted which is often an indication of globe rupture.

13.1.4 B Scanning and CT

B scanning and CT are useful tools in diagnosis of ocular trauma. Ultrasonography can be used to detect internal ocular anatomy and identify intraocular foreign body (IOFD). Ultrasound provides real-time images of the eye and orbit. The relatively high frequency of the sound waves (10 MHz) affords outstanding resolution (0.1–0.01 mm), an ideal choice to image intraocular structures. However, because ultrasound requires direct contact with the eyelids and/or globe, it should not be used in eyes with a high risk of extrusion of intraocular contents (e.g., large wound, uncooperative patient).

Computed Tomography (CT): CT scan has replaced radiography as the most common and useful radiological imaging study in patients with severe peri-/ocular trauma. It is especially useful when orbital fracture or intraorbital/globe metal foreign body is suspected [4–6].

13.1.5 Surgical Management

13.1.5.1 Anesthesia

General Anesthesia: General anesthesia is preferred. It can provide excellent anesthesia and akinesia effect with minimal increase of intraocular/orbital pressure. It is inappropriate in patients who are systemically ill, elderly, or debilitated.

Retrobulbar Anesthesia: It could provide both anesthesia and akinesia effect. However, retrobulbar anesthesia may increase intraorbital and intraocular pressure. Thus, it is recommended only for patients in whom general anesthesia can cause unacceptable systemic side effects.

Topical Anesthesia: Topical approach is of the lowest risk of systemic stress; however, it is only suitable for small, anterior defects and inadequate for the extensive dissection of the conjunctiva and Tenon's capsule as is often required in open globe injury [7].

13.1.5.2 Wound Closure: First Phase Repair

Limbus Wound Suture

If the wound extends through both cornea and sclera, suture should begin at the limbus, using

interrupted 10-0 nylon with depth of 90–100%. Then continue with suture of cornea wound with interrupted 10-0 nylon.

Scleral Wound Suture

Globe exploration should be performed if scleral wound is suspected. A 360° peritomy is made, and Tenon's capsule is retracted posteriorly to reveal the underlying sclera. Scleral wound should be closed from anterior to posterior, beginning from limbus or apex of wound. Anatomically watertight suture is necessary to prevent fibrovascular proliferation through the wound. A 6-0 to 8-0 absorbable thread is recommended. Vitreous should amputate at the scleral surface; however, prolapsed uveal or retinal must be gently reposited if possible. And incarceration in the wound should be avoided. If wound extends under the insertion of extraocular muscle, the muscle could be temporarily disinserted.

Normal functioning of ciliary body is important to maintain normal IOP. It is not uncommon that the eye remains hypotonous even after successful treatment of open globe injury. The possible causes of hypotony include wound leak, cyclodialysis, ciliochoroidal detachment, retinal detachment, iridocyclitis, anterior PVR, and ischemia/necrosis of ciliary body.

Careful eye examination is required to find reasons of hypotony. Surgery is required if leaking wound, cyclodialysis, ciliochoroidal detachment, retinal detachment, and anterior PVR were found. For patients with iridocyclitis, strong cycloplegics and topical corticosteroids should be prescribed as in treatment of anterior uveitis.

Artificial maintenance of globe volume should be considered if dysfunction of ciliary body was the reason for hypotony. When the dysfunction of ciliary is only temporary, repeated air, long-acting gas, or sodium hyaluronate injection could be the options. However, these are not long-term solutions.

Vitreoretinal Surgery: Second Phase Repair

Vitreoretinal involvement accounts for 40% in open globe injuries. Despite successful wound closure, injuries involving posterior segment often lead to total retinal detachment, vitreous hemorrhage, choroidal detachment, and subchoroidal hemorrhage (SCH). Vitreoretinal surgery is usually required for second phase repair.

The exact timing of vitrectomy following open globe injury is of controversy. Most authors recommend waiting for 1–2 weeks following primary surgery, while some prefer performing it at the time of wound closure. A complete vitrectomy should be performed; removal of vitreous face could reduce the chance of proliferative vitreo-retinopathy (PVR). A wide-angle viewing system or scleral depression permits shaving of the vitreous base and thorough examination. Relieve all tractions to achieve complete apposition of retina to RPE. Laser retinopexy or cryopexy can be applied to achieve long-term closure of retinal breaks. Laser photocoagulation is recommended to prevent spread of RPE cells and PVR formation. Silicone oil is preferred for intraocular tamponade. It is recommended that silicone oil is instilled into the eye after retinal reattachment with air-fluid exchange [8–10].

13.1.6 Postoperative Examination and Supplementary Silicon Oil Injection

Routine visual acuity, intraocular pressure, slit lamp, and fundus examinations are required after operation to identify the closure of the wound, the postoperative inflammatory reaction, and the integrity of the globe. Hypotony often occurs in silicon oil tamponade aphakic eyes several days after the operation as the relieving of edema of intraocular tissues and absorption of hemorrhage which lead to insufficient of silicon oil. Supplementary silicon oil injection through limbus tunnel incision is necessary to maintain normal pressure and plumpness of the globe. Repeated silicon oil injection is not rare due to gradual improvement of edema and hemorrhage and the relative increase of intraocular volume (Fig. 13.1a–c).

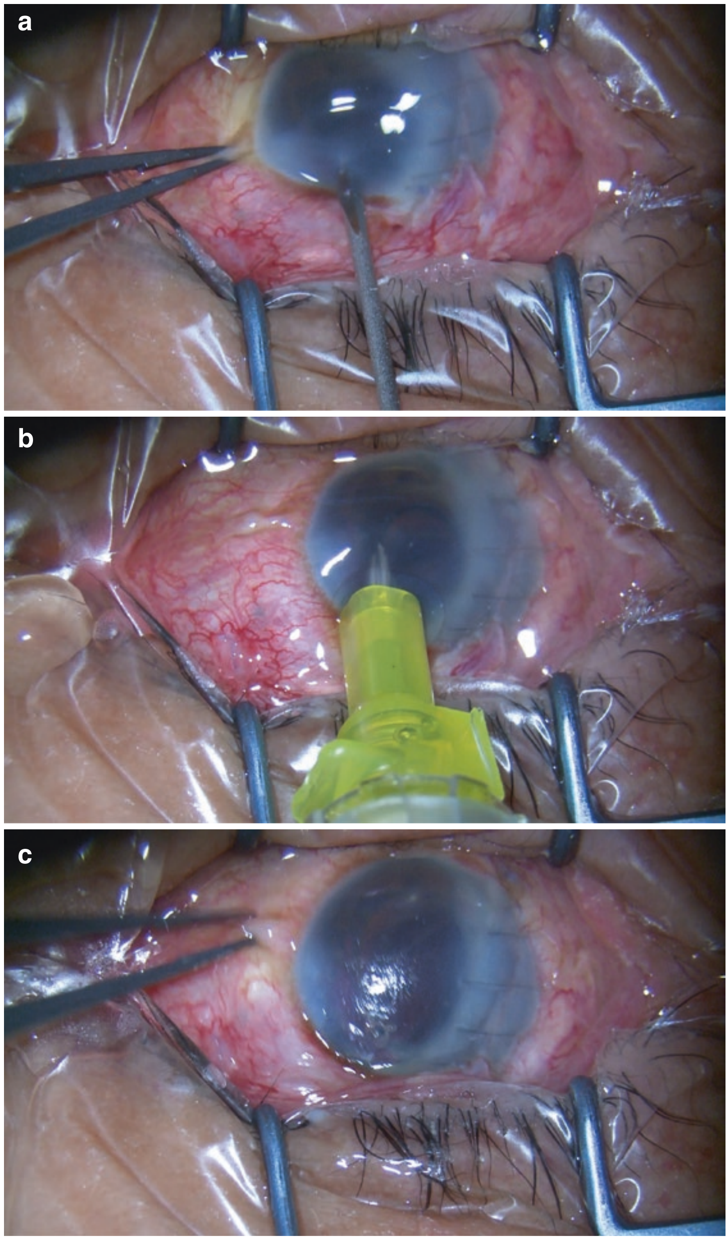

Fig. 13.1 (**a**) Superior limbal tunnel incision was performed with a 20-gauge MVR knife. (**b**) Silicon oil was injected into the eye with a 24-gauge intravenous catheter cut short in advance. (**c**) The incision was self-closing without suture after supplementary silicon oil injection

13.1.7 Silicone Removal

Silicone oil removal is allowed after a minimum of 8 weeks after surgery. Removal within the first 6 months after surgery is usually recommended; however, it depends. Various techniques are used for SO removal. Usually, a two-port system is preferred: one port is used for the infusion, either from the corneal or from the pars plana, and the other is used for aspiration of SO. After the removal of the oil, the same port can be used for internal search using a light pipe combined

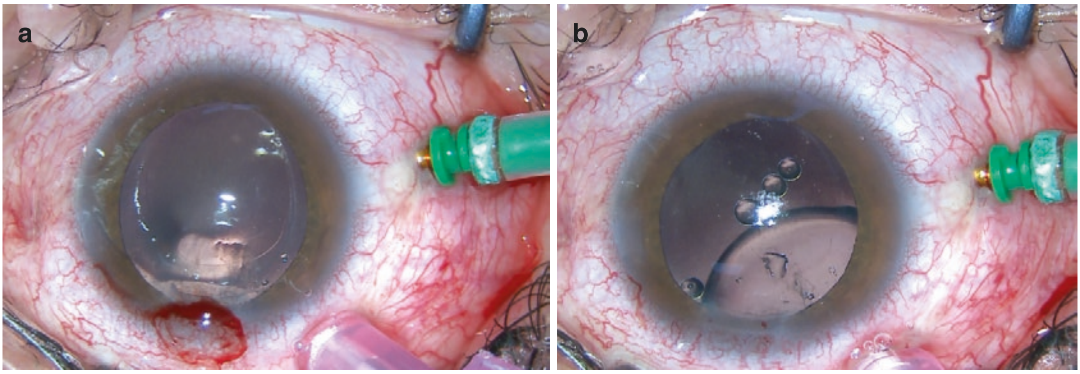

Fig. 13.2 (**a**) Two-port system is preferred: one port is used for the infusion, and the other is used for aspiration of silicone oil. (**b**) Silicone oil is almost aspired out when bulb margin appears

with scleral indentation. Additional maneuvers may be needed such as removal of epi-retinal membranes that might be present or a repeated fluid-air exchange to encourage a more complete removal of the SO. The length of the aspirating cannula is important. A short cannula is always preferred. During the removal of SO, it is important that the cannula stays within the main bubble. If the cannula comes out of the SO bubble, the individual bubble of oil can be isolated and left behind (Fig. 13.2a, b).

13.1.8 Ocular Preserving by Silicon Oil Tamponade

Nowadays, as we preserve more and more eyes with severe trauma, it is increasingly common for ophthalmologists to treat eyes gradually becoming phthisical during follow-up due to ciliary body dysfunction. In the past these eyes were usually enucleated. However, our experience shows that silicone oil can maintain the IOP and mechanically prevent the eye from shrinking. Long-term silicone oil tamponade may be helpful for the patients' cosmetic reasons and psychological comfort. Meanwhile, for doctors, the technique is not difficult to master and could help us to avoid potential conflict.

The main complications for this technique include corneal fistula, sympathetic ophthalmia, and silicone oil emulsification. Self-scleral flap is useful for corneal fistula that could not be sutured. Emulsified silicone oil could be easily removed and re-instilled. The incidence of sympathetic ophthalmia is rare in our observation and could be controlled by corticosteroid.

13.1.9 Cosmetic Management and Pain Relief by Conjunctival Flap

For those ruptured eyes with no light perception, conjunctival flap can be applied for cosmetic improvement or for pain relief. Wearing artificial eyeshade after conjunctival flap, patients with severe eye trauma resulting in NLP of the eyeball can achieve self-confidence by normal looking. The technique for conjunctival flap can be divided into three steps: (1) 360° dissection of the conjunctiva, (2) removal of 1/3–1/2 thickness of the cornea especially the epithelium layer, and (3) suturing the conjunctiva with absorbable suture. Three months after the surgery, artificial eyeshade can be applied to the conjunctival sac to achieve normal looking of the eyeball (Fig. 13.3a–c).

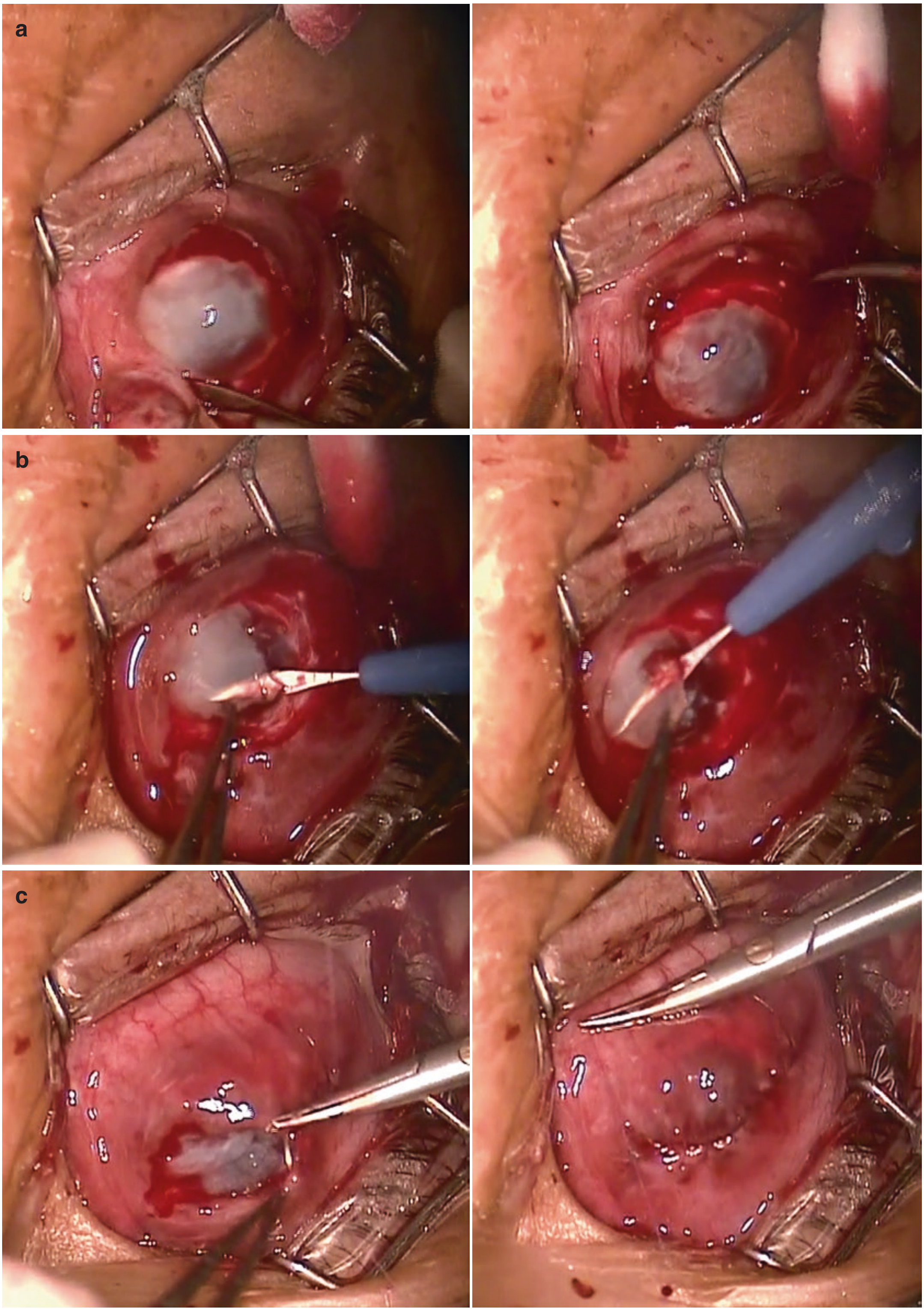

Fig. 13.3 (**a**) Step 1: 360° dissect the conjunctiva. (**b**) Step 2: remove 1/3–1/2 thickness of the cornea especially the epithelium layer. (**c**) Step 3: suture the conjunctiva with 6-0 Vicryl

13.2 Cases

13.2.1 Case 1

A 33-year-old male, the right eye was hit by an elbow accidentally 1 day ago. Severely swollen lids with extensive ecchymosis, intense conjunctival chemosis, and wide-range conjunctival hemorrhage, indicating ocular rupture (Fig. 13.4a–n).

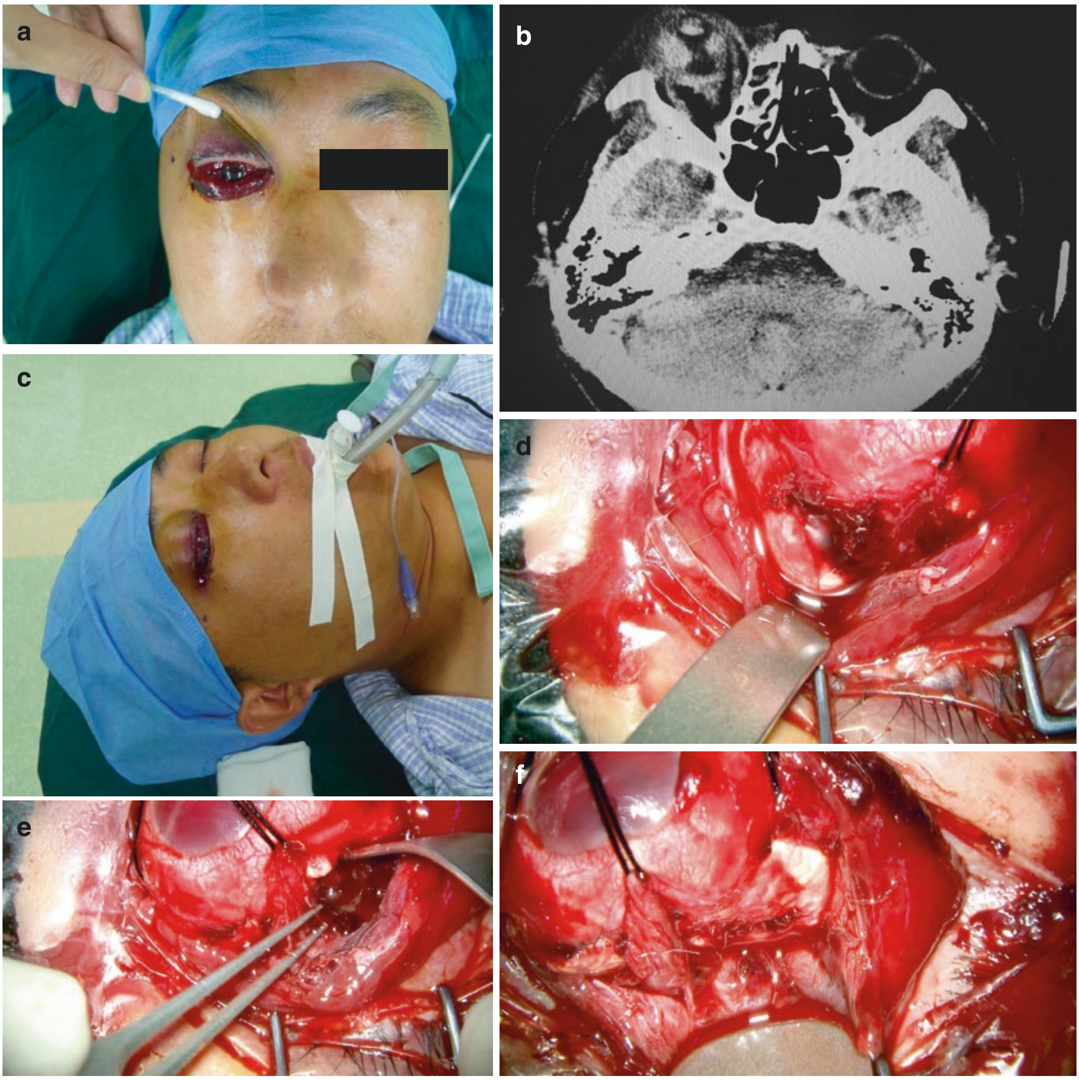

Fig. 13.4 (**a**) A 33-year-old male, the right eyeball was injured by an elbow during exercise (12-7-24). (**b**) CT scan showing wall of globe was incomplete. (**c**) General anesthesia is recommended for open globe injury. (**d**) First phase repair (12-7-27): Globe exploration: 360° peritomy is made, and Tenon's capsule is retracted posteriorly to reveal the underlying sclera; nasal of superior rectus is exposed. (**e**) Temporal of superior rectus is exposed, and rupture of sclera with protrusion of choroid and retinal tissue is shown. (**f**) Watertight suture using interrupted 8-0 absorbable thread. Prolapsed uveal or retinal tissue was reposited. (**g**) Second phase repair (2012-8-3): drainage of suprachoroidal hemorrhage (SCH). (**h**) Three-tunnel vitrectomy was performed. (**i**) Clearance of vitreous hemorrhage. (**j**) Reposition of retina under perfluorocarbon and laser photocoagulation. Gas-perfluorocarbon exchange. (**k**) Silicone oil tamponade. (**l**) Cosmetic appearance (2012-8-14). (**m**) Follow-up 3 months after surgery, IOP 12 mmHg, BCVA0.15, silicone oil emulsification (2012-11-19). (**n**) After removal of silicone oil, BCVA0.12, IOP 12 mmHg (2013-3-11)

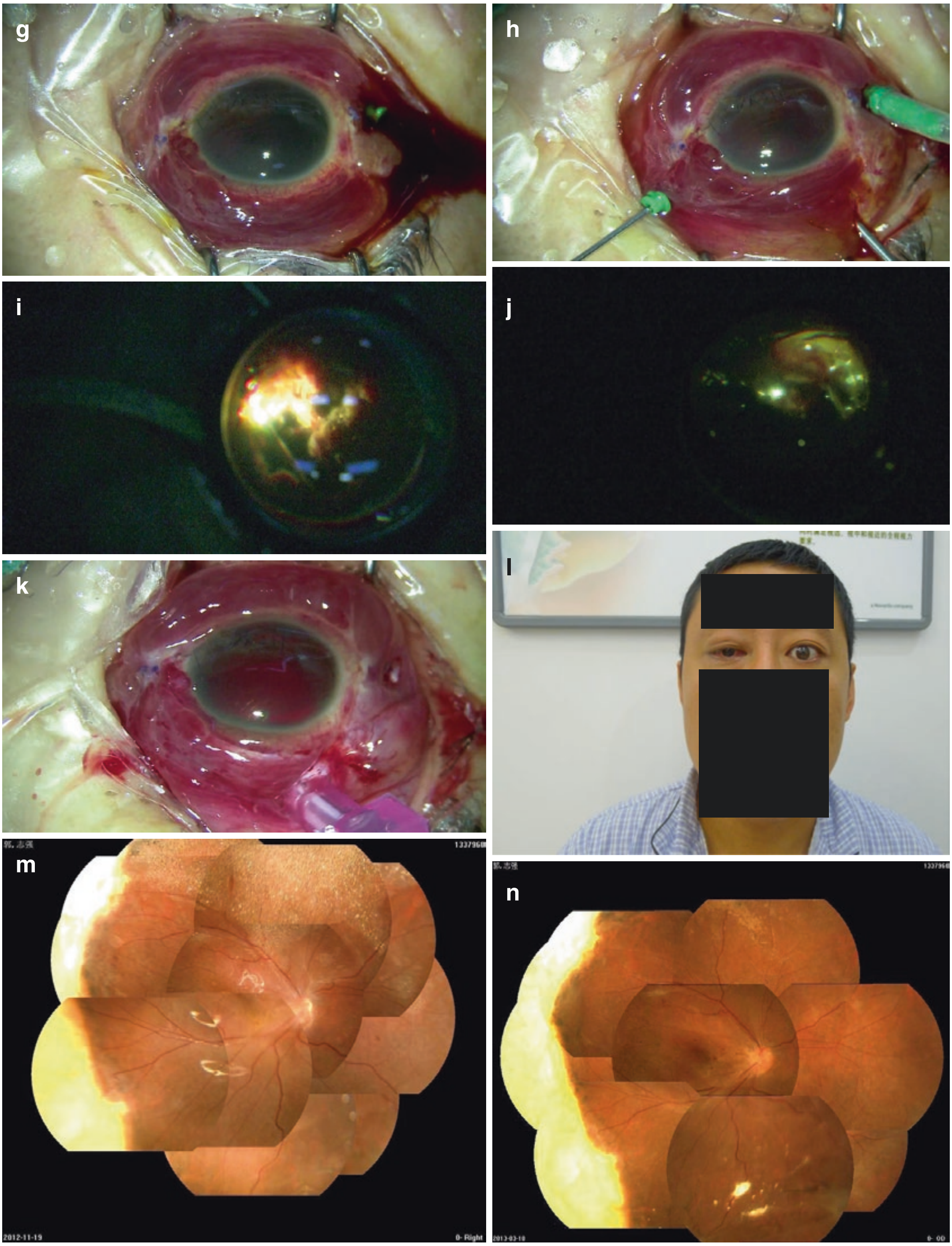

Fig. 13.4 (continued)

13.2.2 Case 2

A 22-year-old male, the left eyeball was injured by piece of glass during basketball game; suture was completed locally and presented to clinic with severe conjunctival chemosis (Fig. 13.5a–p).

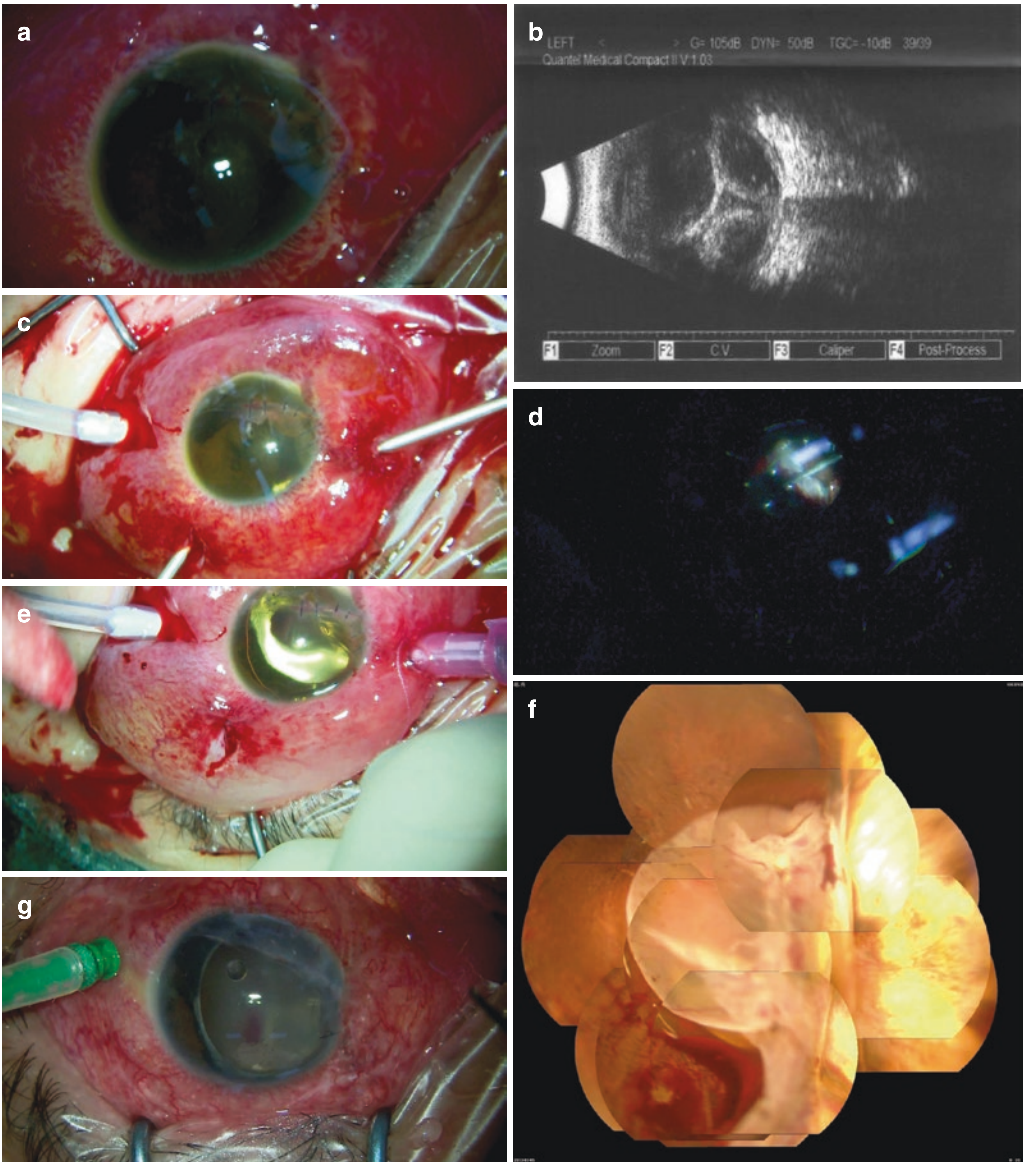

Fig. 13.5 (**a**) A 22-year-old male, the left eyeball was injured by piece of glass during basketball game; suture was completed locally. (**b**) Ultrasonography showing bullous choroidal detachments. (**c**) Vitrectomy for the first time (13-1-17): three-tunnel vitrectomy. (**d**) Clearance of vitreous hemorrhage and reposition of retina. (**e**) Silicone oil tamponade. (**f**) First day after surgery, patient complained light perception. (**g**) Supplementary silicone oil injection repeated for three times through limbal incision, IOP stable at 12 mmHg. Follow-up 2 months after surgery (2013-3-5). (**h**–**k**) Vitrectomy for the second time (2013-3-7). (**i**) Bimanual manipulation with direct illumination of microscopy. (**l**) Reposition of retina under perfluorocarbon. (**m**) Gas-perfluorocarbon exchange. Silicone oil tamponade. (**n**) Four days after surgery BCVA0.02 (2013-3-11). (**o**) Follow-up 3 weeks after surgery, BCVA0.15 (2013-3-24). (**p**) Follow-up 1.5 years after surgery, BCVA0.1, IOP 8.6 mmHg, cosmetic appearance (2014-11-8)

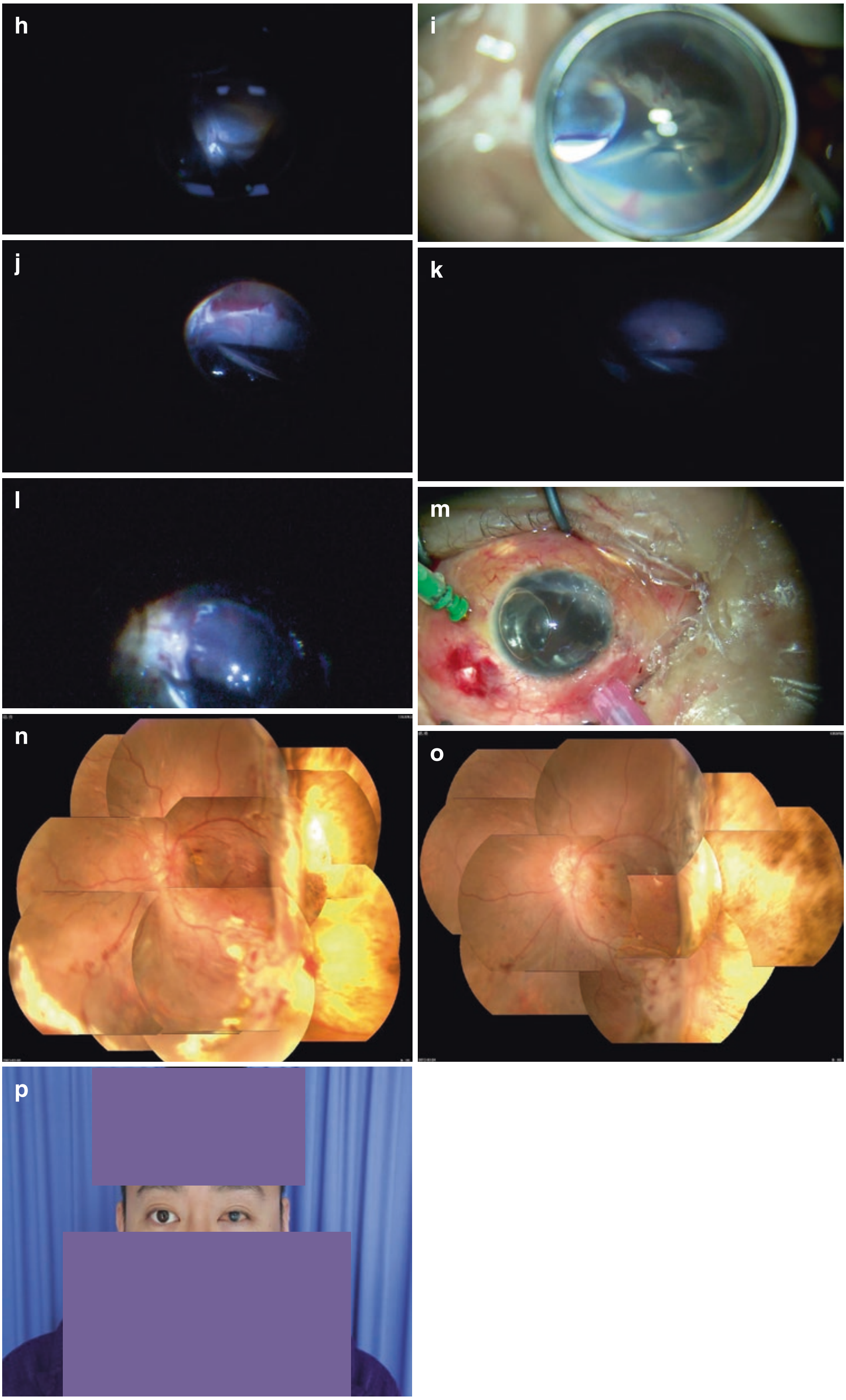

Fig. 13.5 (continued)

13.2.3 Case 3

A 43 year old male, left eye was injured in an traffic accident. he was diagnosed as eyeball rupture and was sutured in the local hospital. Physical examination revealed eye lids edema and conjunctival chemosis when he presented at clinic (Fig. 13.6a–j).

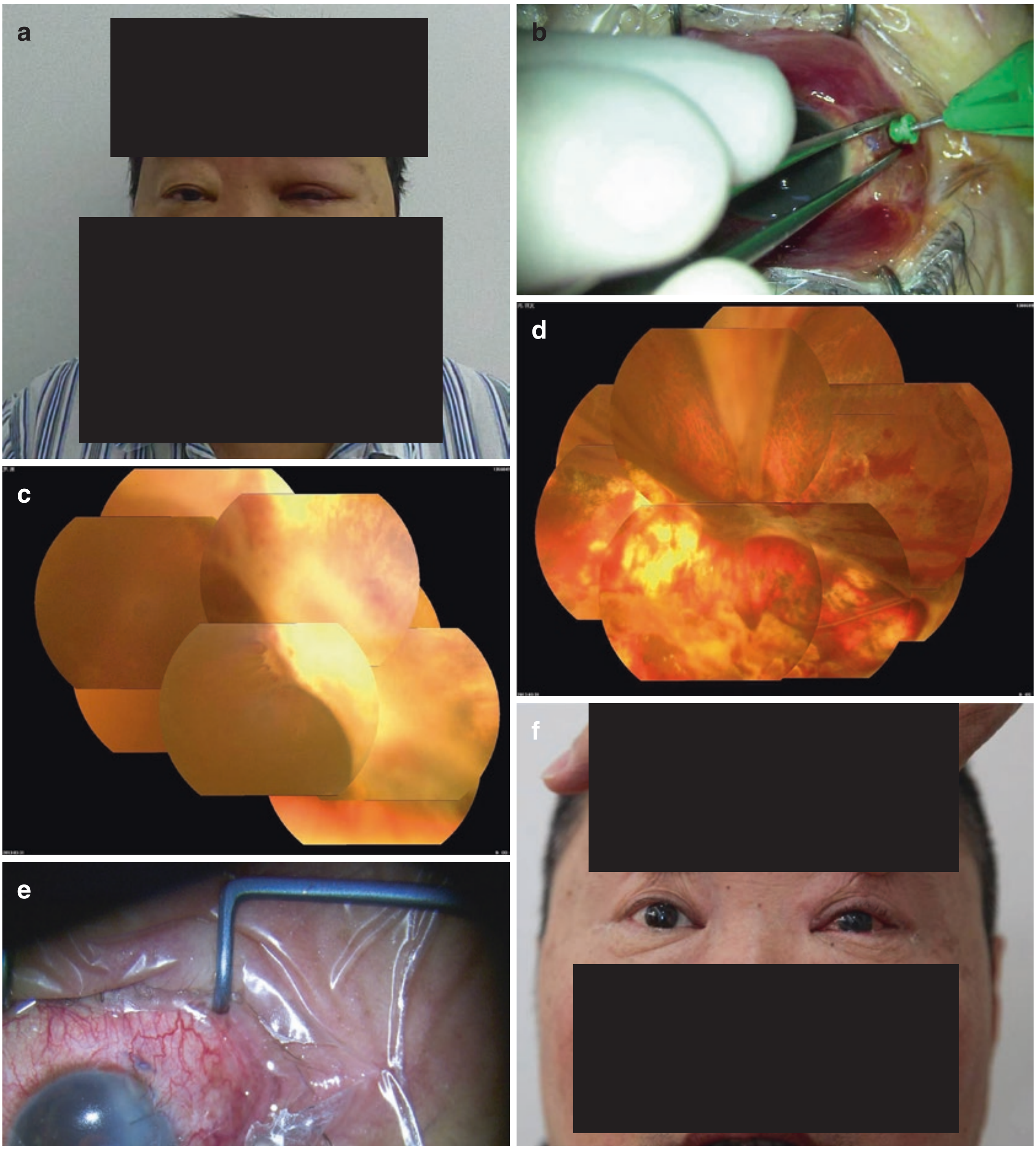

Fig. 13.6 (**a**) Male patient, 2011.11.7, the left eye ruptured. (**b**) Sutured in local hospital. Vitrectomy performed. (**c**) Extensive detachment and loss of choroid were found. (**d**) Silicone oil tamponade, and the remaining retina reattached. (**e**) Repeated injection of silicone oil for four times to maintain normal IOP. (**f, g**) Silicone oil tamponade eye with excellent cosmetic appearance. (**h**) Corneal fistula developed in 2015.3.16. (**i**) Self-scleral flap was inserted into corneal stroma to cover fistula. Two weeks after surgery. (**j**) Three months after surgery, fistula was successfully covered

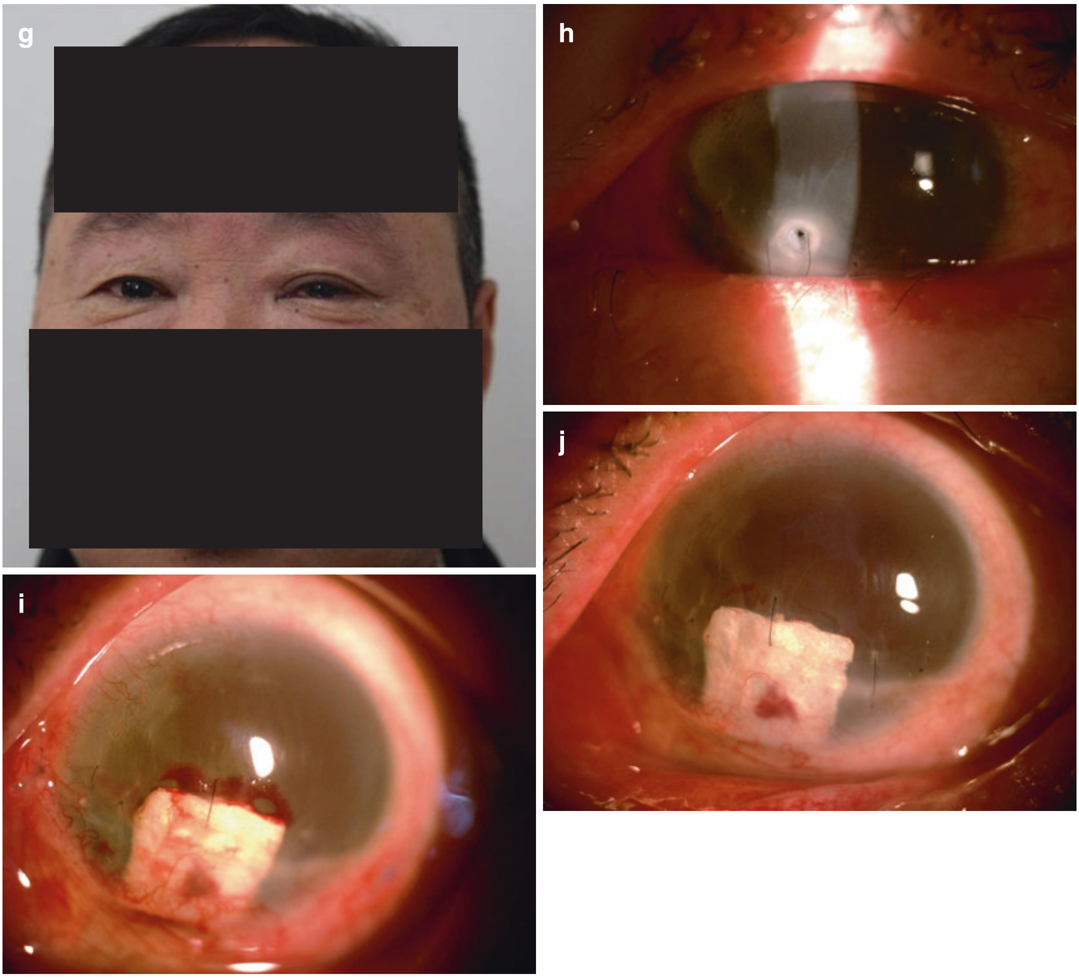

Fig. 13.6 (continued)

13.2.4 Case 4

A 45-year-old male with bullous keratopathy of the right eye 7 years after severe eye trauma with complaint of pain and difficulty of opening eyes. No light perception of the right eye. Conjunctival flap was performed for cosmetic improvement and pain relief (Fig. 13.7a–d).

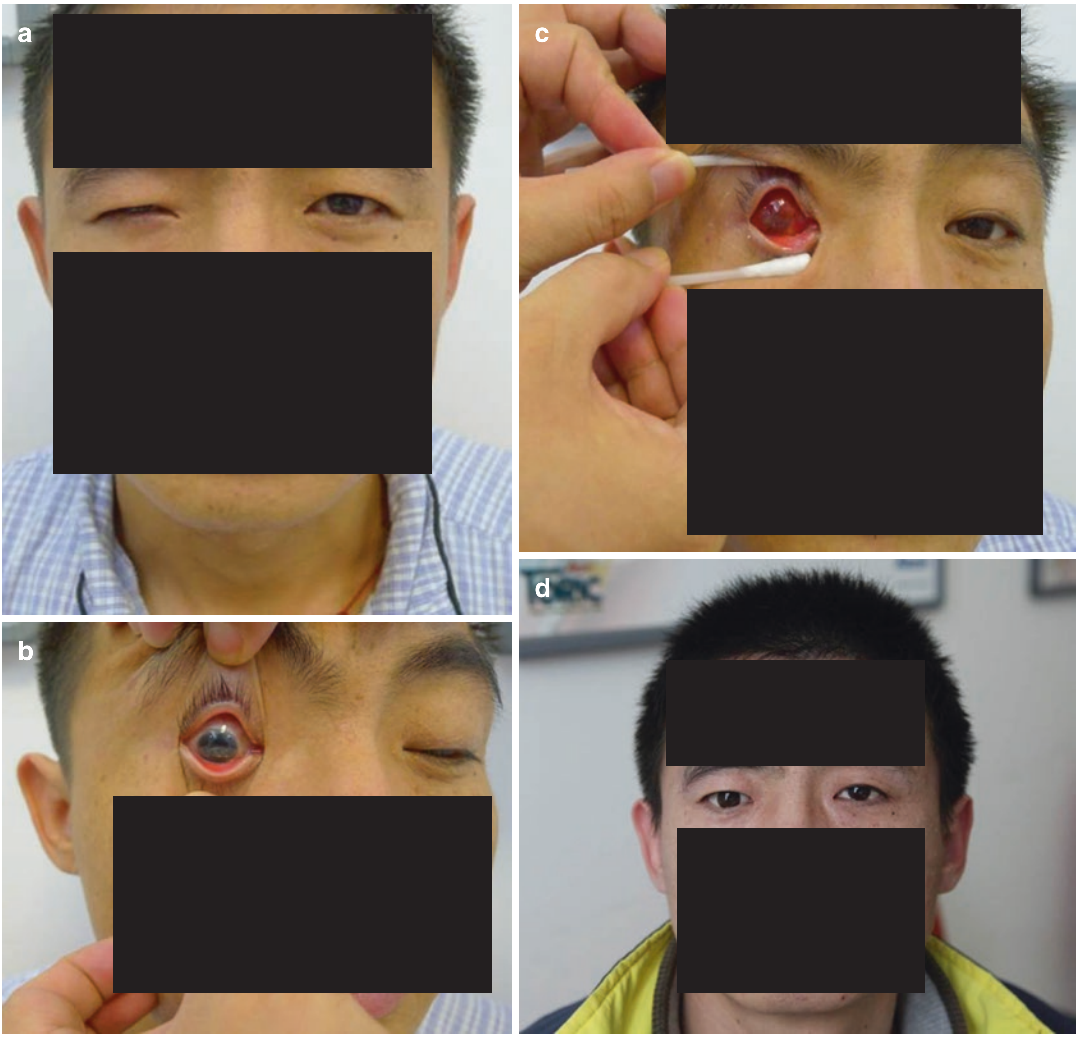

Fig. 13.7 (**a**) General appearance before the surgery. (**b**) Eyeball appearance before the surgery. (**c**) Eyeball appearance 1 week after surgery. (**d**) General appearance 1 year after surgery

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14 Ocular Chemical Burns

Weiyun Shi and Ting Wang

Abstract

Ocular chemical burn is a serious emergency in the eye, usually caused by acid or alkali. Ocular chemical burns can cause acute vision loss and severe and permanent tissue damage; even after repairing and healing, there will be many complications, such as symblepharon, which will also greatly affect the appearance. This chapter includes five cases with brief descriptions, illustrating figures and personal tips and tricks, aiming to providing a guide about diagnosis and management of ocular chemical burns.

Keywords

Ocular chemical burns · Amniotic membrane transplantation · Keratoplasty · Symblepharon

14.1 Introduction

Ocular chemical burns are true ophthalmic emergencies due to the potential for permanent corneal and intraocular damage leading to visual impairment and even blindness [1, 2] (Figs. 14.1 and 14.2). The offending chemical substances include industrial and domestic cleaning agents,

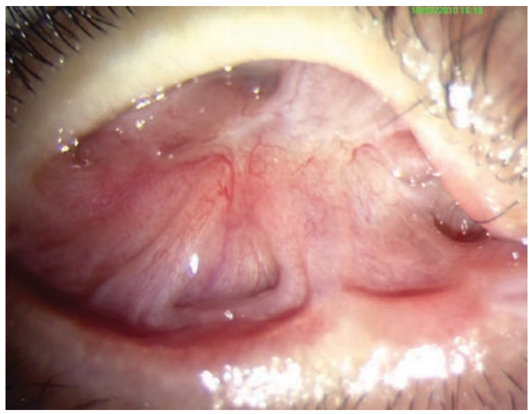

Fig. 14.1 Blinding severe acid burn

Fig. 14.2 Blinding severe alkali burn

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cements, plasters, fertilizers, limes, and fireworks [2]. Acids and alkalis are most frequently associated with significant chemical injuries to the eye. The severity of the burns depends on many factors, including the concentration and pH of the solution, the extent of ocular surface exposure, and the duration of ocular exposure before treatment [3].

Cements, ammonia, lye, limes, potassium hydroxide, and magnesium hydroxide are common alkaline agents [4]. Strong alkalis can penetrate the eye rapidly, causing very severe ocular injuries. Aqueous humor pH changes are detectable within a few seconds of contact with sodium hydroxide or ammonium hydroxide [5, 6]. Fireworks may contain magnesium hydroxide, and thus the related ocular burns are both chemical and thermal in nature.

The major offending acidic substances include sulfuric, hydrofluoric, chromic, acetic, and hydrochloric acids [2]. The strength of an acid is based on its ability to lose a proton, and a strong acid can completely ionize in an aqueous solution.

The penetration of a chemical to ocular tissues impacts on the subsequent injury severity. Alkalis typically invade the eye more rapidly than acids [2, 5] and usually cause the most severe chemical damages. However, very strong acids may penetrate as rapidly as alkalis. It was reported that there was no significant difference in the clinical course and prognosis between severe alkali and acid injuries [7].

14.2 Case #1: The Eye Burned by Low Concentration Alkali

14.2.1 Case Description

A 43-year-old male visited us 1 h after the right eye was injured with low-concentration alkali solution and washed immediately with a lot of clear water. The visual acuity was finger counting at 10 cm. A transverse zonal opacity in the central and superficial cornea was observed (Fig. 14.3). After a second eye flushing, amniotic membrane transplantation was performed instantly (Fig. 14.4). At 2 weeks, the amniotic membrane was removed. Corneal transparency was restored (Fig. 14.5), and the vision was improved to 0.8, owing to the mild burning, with only the corneal epithelium involved, and timely treatment.

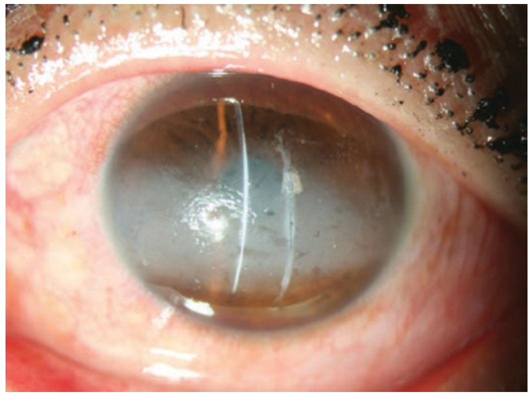

Fig. 14.3 A transverse zonal corneal opacity located in the superficial layer

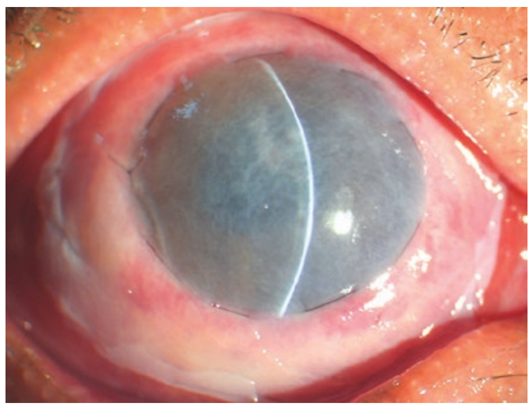

Fig. 14.4 On day 1 after amniotic membrane transplantation

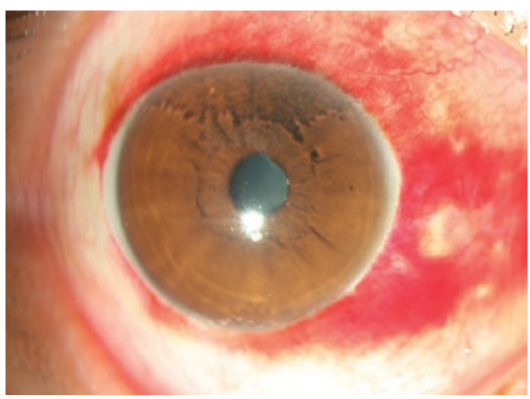

Fig. 14.5 The clear cornea after amniotic membrane removal

14.3 Case #2: The Eye Damaged by Strong Alkaline Solution

14.3.1 Case Description

A 56-year-old male patient presented with visual acuity of light perception before the eye and intraocular pressure of 35 mmHg 1 day after the eye was damaged by strong alkaline solution. The conjunctiva was wholly ischemic and necrotic; the entire cornea was cloudy, edematous, and porcelain white; the inner eye was invisible (Fig. 14.6). Amniotic membrane transplantation was performed three times after admission to the hospital, and the eye globe was preserved. The conjunctival necrosis and severe stem cell deficiency identified a poor prognosis. Symblepharon developed at 5 months (Fig. 14.7).

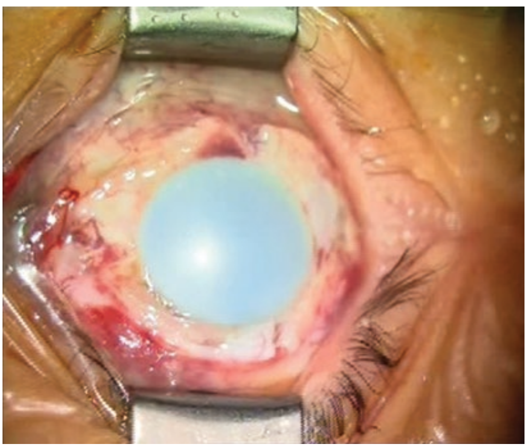

Fig. 14.6 Ischemia and necrosis in the whole conjunctiva and completely white opacity and edema in the cornea, with invisibility of the inner eye

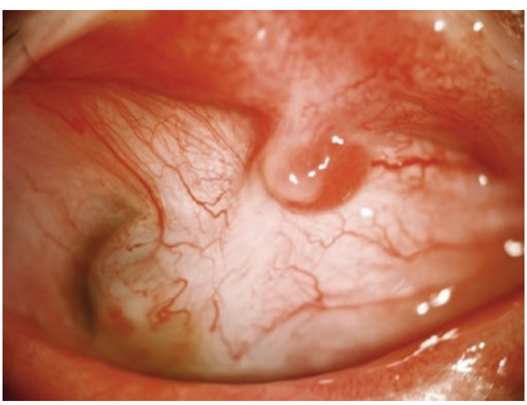

Fig. 14.7 Symblepharon with pseudopterygia growing onto the cornea

14.4 Case #3: Symblepharon Caused by Alkali Burn

14.4.1 Case Description

A 48-year-old male patient presented with difficulty in eye rotation 1 year after alkali burn. Examinations revealed visual acuity of 0.2 and the inferior cornea with symblepharon and pseudopterygium close to the pupillary limbus (Fig. 14.8). A semicircular keratoplasty with the corneal limbus was performed, achieving good results. The adhesion was separated, and the eye globe could move freely (Fig. 14.9). The vision recovered to 0.5.

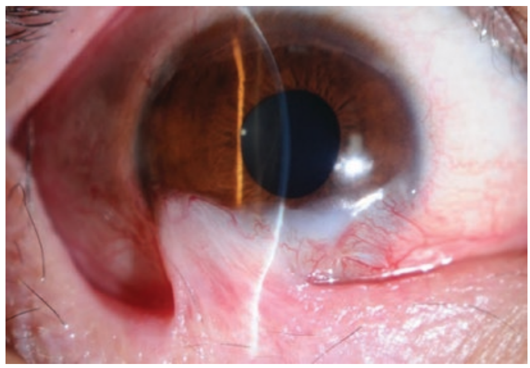

Fig. 14.8 Symblepharon and pseudopterygium covering the inferior cornea and close to the pupillary limbus

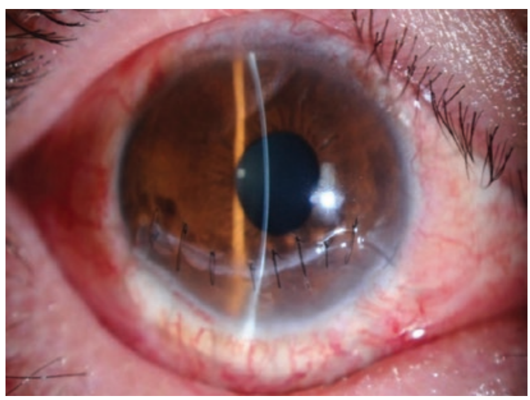

Fig. 14.9 Separation of symblepharon after semicircular keratoplasty with the corneal limbus

14.5 Case #4: The Eye Burned by Acidic Solution

14.5.1 Case Description

A 48-year-old male visited us 1 day after acidic solution into the eye, presenting with eye pain and decreased visual acuity. There were epithelial defect, edema, and foggy turbidity in the cornea (Fig. 14.10). Emergency amniotic membrane transplantation was performed (Fig. 14.11). At 2 weeks, the amniotic membrane was removed. The epithelium healed with remnant pannus on the cornea. The visual acuity was improved from preoperative 0.02 to postoperative 0.6 (Fig. 14.12).

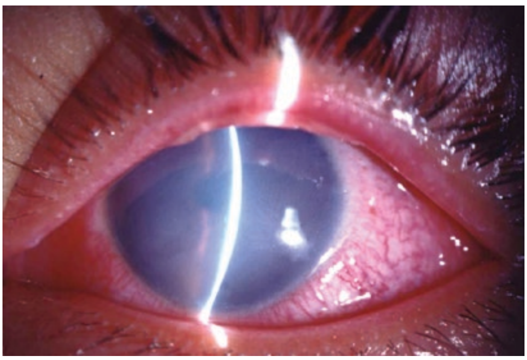

Fig. 14.10 Corneal epithelial defect and edematous opacity after acid burn

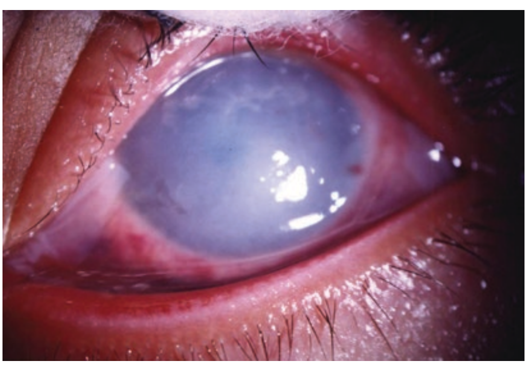

Fig. 14.11 Amniotic membrane covering the ocular surface

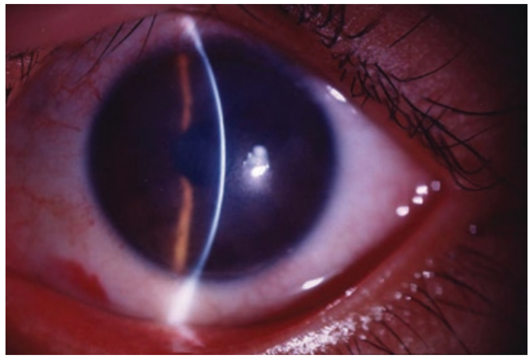

Fig. 14.12 Regression of corneal edema and presence of pannus after amniotic membrane removal

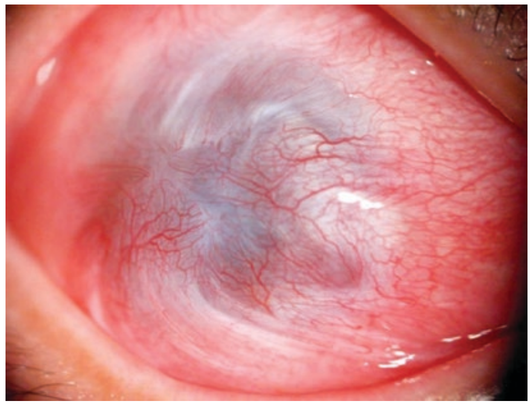

Fig. 14.13 Corneal pannus leading to invisibility of the inner eye

14.6 Case #5: The Eye Burned by Acid

14.6.1 Case Description

A 53-year-old male patient visited us half a year after acid burn. The vision was hand movement before the eye. A large area of corneal pannus was observed to grow onto the cornea. The anterior chamber could not be clearly seen (Fig. 14.13). Stem cells cultured on amniotic membrane were transplanted to release symblepharon (Fig. 14.14), before the second surgery of lamellar keratoplasty with the corneoscleral limbus combined with partial tarsorrhaphy. Postoperatively, the corneal graft and bed were transparent, and the pupil was visible (Fig. 14.15). The visual acuity was improved to 0.5.

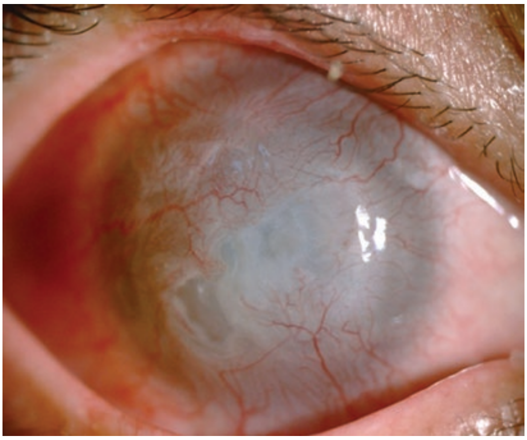

Fig. 14.14 Released adhesion after transplantation of stem cells cultured on amniotic membrane

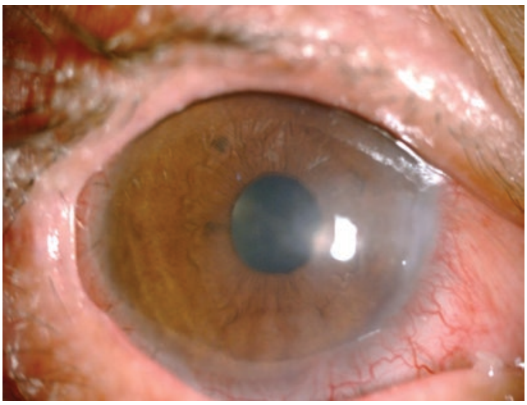

Fig. 14.15 The clear corneal graft and bed after combined lamellar keratoplasty with the corneoscleral limbus and partial tarsorrhaphy

14.7 Tips and Pearls

14.7.1 Medical Therapy

1. Emergency management
   Irrigation of the eye. It is better to wash the eye within 3 min after chemical burn. A drop of anesthetic can be instilled first in the conjunctival sac if possible, then followed by adequate eyelid opening and foreign body removal. Continuous eye flushing for at least 30 min is more effective.

   Paracentesis of the anterior chamber. Alkali substance may penetrate the anterior chamber within 3 min; it can be recovered to normal in 1–3 h. It is useless if the paracentesis is performed at 1 day after the injury.

   Bulbar conjunctival incision. A radial incision of the bulbar conjunctiva before anterior chamber irrigation is helpful to dilute the subconjunctival chemical substances.

   Heparin application. Heparin can improve the restoration of blood circulation after conjunctival vascular embolization and atresia generated by chemical burn. The solution of 1000–2000 units/mL may be topically used, until the blood vessels at the corneal limbus become dilated.
2. Corneal contact lenses. Soft contact lenses can promote the repair of the corneal ulcer and epithelium defect. However, due to the reduction of corneal oxygen supply and increased risk of infection during lens wear, this approach has been uncommon.
3. Administration of corticosteroids. Corticosteroids can reduce inflammation and inhibit proliferation of capillaries. We should note that corticosteroids can stimulate collagen activity and increase the dissolution of corneal tissue. Improper use can result in corneal perforation. If there is no corneal ulcer within 1 week after chemical burn, systemic and topical use of corticosteroids is recommended. After 1 week, corticosteroids can be tapered or stopped and replaced with nonsteroidal medicines.
4. Use of collagen agents. Administration of 0.2% EDTA is useful in the prevention of corneal lamellar dissolution.
5. Prevention of infection. Systemic and local use of antibiotics can be considered.

14.7.2 Surgical Management

1. Amniotic membrane transplantation as the most effective treatment to chemical burn should be performed as soon as possible regardless of the type of injuries.
2. Surgical treatment for the late-stage complications includes adhesion separation and formation, corneal limbal stem cell transplantation,

lamellar keratoplasty, penetrating keratoplasty, corneal transplantation with the corneoscleral limbus, and penetrating keratoplasty combined with stem cell transplantation.

14.8 Highlights

Double continuous sutures are recommended for amniotic membrane transplantation. The very few suture knots on the ocular surface help to reduce the postoperative irritation. The close attachment of amniotic membrane to the ocular surface facilitates epithelial growth. In the process of amniotic membrane covering, whether to open the bulbar conjunctiva depends on the severity of damage to the eye. When the anterior chamber is extensively ischemic and necrotic, vascular tissue blocked by microthrombus on the conjunctival and sclera surface can be massaged for recovery of blood supply after the bulbar conjunctiva is cut open. Then the conjunctiva is covered on the corneoscleral surface and amniotic membrane surface. If the ischemia is not serious, it is unnecessary to open the bulbar conjunctiva, and mere amniotic membrane covering is feasible [8].

In case a chemical corneal wound is about to be perforated, corneal transplantation is imperative. After surgery, attention should be paid to the abnormality of tears. Once the epithelial healing is delayed, measures need to be taken early. When scars occur, it is recommended to make a tear test. The corneal epithelium is liable to heal after keratoplasty with protection from tears. Otherwise the corneal graft may dissolve.

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15 Ocular Thermal and Radiation Burns

Weiyun Shi and Ting Wang

Abstract

Ocular thermal and radiation burns are usually caused by molten iron, hot water, hot oil, and ultraviolet and infrared rays and can easily bring about erythema, blisters, and edema and even lead to deep burns of eye tissue and tissue necrosis, which can bring about acute loss of vision and damage of the eye structure, such as the cornea and sclera, and may result in severe visual and facial defects in the later period. This chapter includes four cases with brief descriptions, illustrating figures and personal tips and tricks, aiming to provide a guide about diagnosis and management of ocular thermal and radiation burns.

Keywords

Ocular thermal and radiation burns · Lamellar keratoplasty · Penetrating keratoplasty

15.1 Introduction

Facial burns are a common component of thermal injuries, and eye involvement has been reported in 7.5–27% of patients admitted to burn units [1]. The majority of thermal ocular burns can be categorized into flame burns and contact burns. Flame burns are secondary to fire, and contact burns are the result of direct exposure to a hot object [2].

Both ultraviolet and infrared rays can cause radiant injury to the eye. Burns from ultraviolet rays occur more frequently and often result from reflected sunlight or welding light [3]. Ultraviolet burns manifest with pain, blepharospasm, and tearing. Ocular examinations reveal the presence of punctate epithelial erosions and conjunctival hyperemia. Injuries from infrared rays are uncommon and may be caused by explosions or solar eclipses. Although the damage is usually limited to superficial punctate keratitis, prolonged infrared light may induce cataract or chorioretinitis [2].

15.2 Case #1: The Eye Burned by Molten Iron

15.2.1 Case Description

A 38-year-old male patient presented with eye pain and decreased visual acuity at 2 h after a molten iron injury to the eye. The vision was 0.4. The cornea, eyelids, and eyelashes were burned, with iron scraps in the conjunctival sac (Fig. 15.1). Emergency amniotic membrane transplantation was performed to relieve the injury (Fig. 15.2). At 2 weeks, the amniotic membrane was removed, and the cornea was found to heal well (Fig. 15.3).

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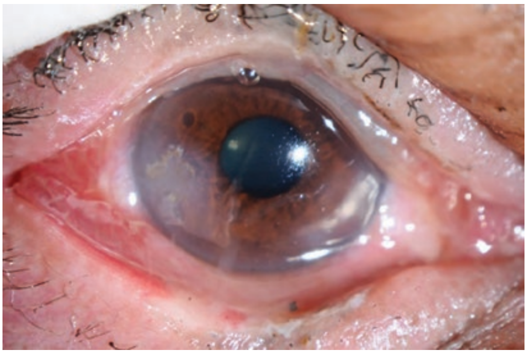

Fig. 15.1 The burned eyelashes, eyelids, and cornea, with iron scraps in the conjunctival sac

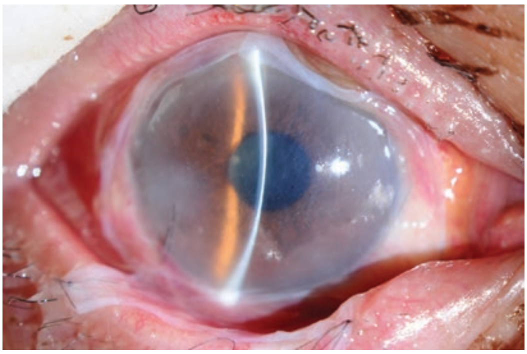

Fig. 15.2 Amniotic membrane covering

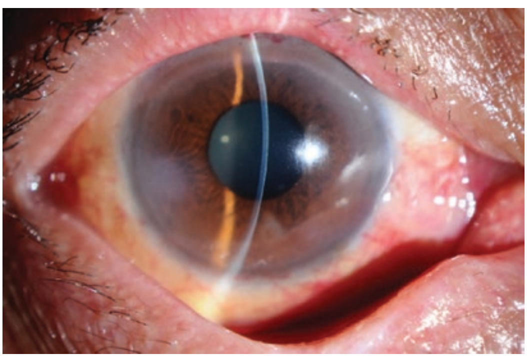

Fig. 15.3 Relieved corneal burn and epithelial healing after amniotic membrane removal

15.2.2 Tips and Pearls

Amniotic membrane transplantation is also useful for ocular thermal burn. Double continuous sutures are recommended for amniotic membrane transplantation. The very few suture knots on the ocular surface help to reduce the postoperative irritation. The close attachment of amniotic membrane to the ocular surface facilitates epithelial growth.

15.3 Case #2: The Eye Burned by Molten Iron

15.3.1 Case Description

A 58-year-old male patient visited us 1 month after the eye was burned by molten iron. The visual acuity was finger counting at 10 cm. The cornea dissolved in an area of about 9 mm, with partial Descemet membrane bulging at 4 mm. There was ischemia in the inferonasal conjunctiva (Fig. 15.4). OCT examination showed that only Descemet membrane remained at the thinnest corneal part (Fig. 15.5). After the necrotic and dissolved corneal tissue was excised, partial lamellar keratoplasty combined with suture of temporal partial palpebral fissure was performed (Fig. 15.6). The postoperative recovery was good, with visual acuity of 0.6.

15.3.2 Tips and Pearls

Keratoplasty should be performed for the late complications including corneal dissolving, corneal limbal stem cell transplantation, and adhesion

Fig. 15.4 The corneal dissolution in an area of about 9 mm, partial Descemet membrane bulging at 4 mm, and inferonasal conjunctival ischemia

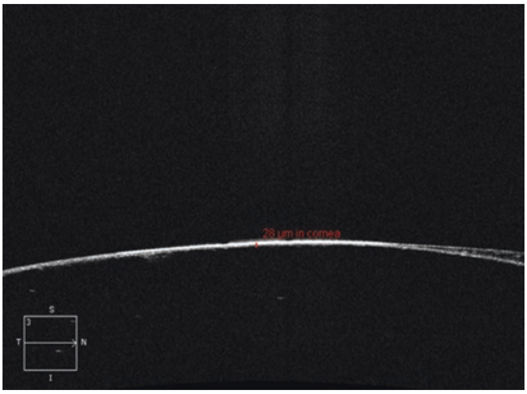

Fig. 15.5 OCT examination demonstrating only Descemet membrane remained at the thinnest corneal part

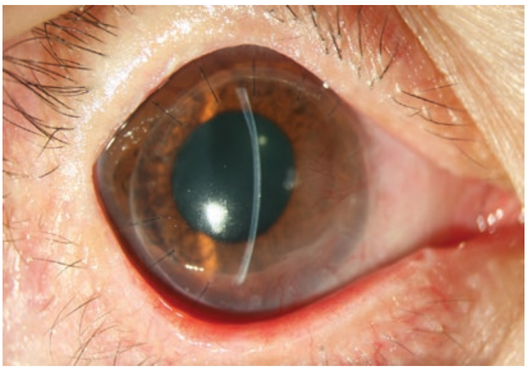

Fig. 15.6 Appearance after partial lamellar keratoplasty in combination of temporal partial palpebral fissure suture

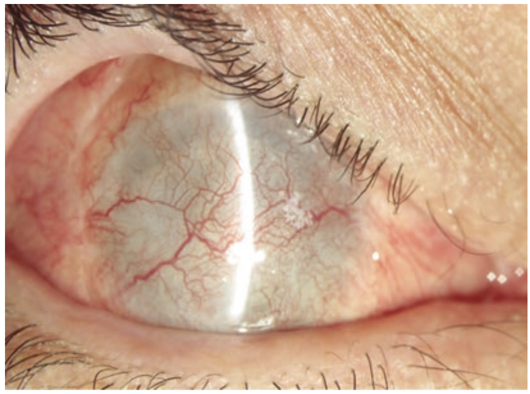

Fig. 15.7 Corneal neovascularization and white opacity, a pupil of approximately 7 mm, and lens turbidity

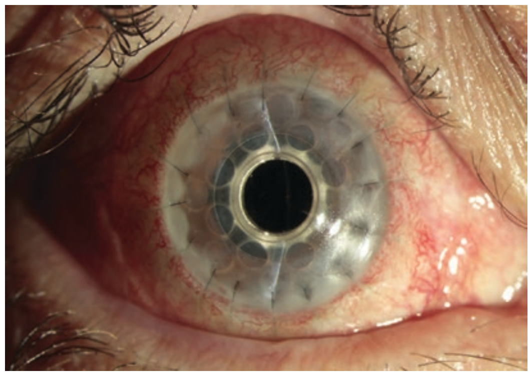

Fig. 15.8 Appearance after cataract extraction with transplantation of a keratoprosthesis

separation and formation. Partial lamellar keratoplasty combined with suture of temporal partial palpebral fissure was performed for this patient and was effective.

15.4 Case #3: The Eye Burned by Molten Aluminum

15.4.1 Case Description

A 28-year-old male patient presented half a year after a burn injury to the eye due to molten aluminum. The visual acuity was hand movement before the eye, and the IOP was 18 mmHg. Neovascularization and white opacity were observed in the cornea, accompanied with a pupil of approximately 7 mm and lens turbidity (Fig. 15.7). After treatment with cataract extraction and transplanting a keratoprosthesis (Fig. 15.8), the visual acuity recovered to 0.5.

15.4.2 Tips and Pearls

Keratoprosthesis is the final measure for the treatment of advanced severe burns. Limbal stem cell deficiency, symblepharon, and existing visual function are surgical indications of keratoprostheses.

15.5 Case #4: The Eye Burned by Ultraviolet Lamplight

A 28-year-old male had eye pain and tearing for 2 h after exposure to ultraviolet lamplight. The visual acuity was 0.3, and the IOP was 16 mmHg, with rough punctuate epithelial opacities (Fig. 15.9). The symptoms disappeared, and the corneal epithelium became normal after 2 days of eye patching with the use of ophthalmic ointments (Fig. 15.10). The vision was improved to 1.0.

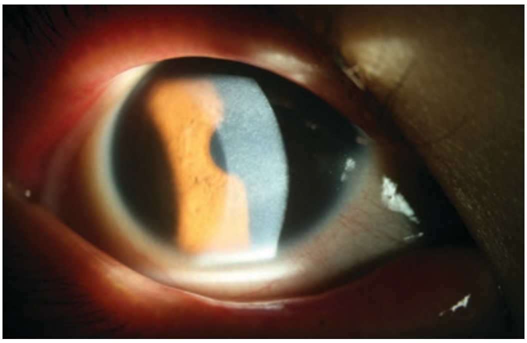

Fig. 15.9 Rough punctuate intraepithelial opacities

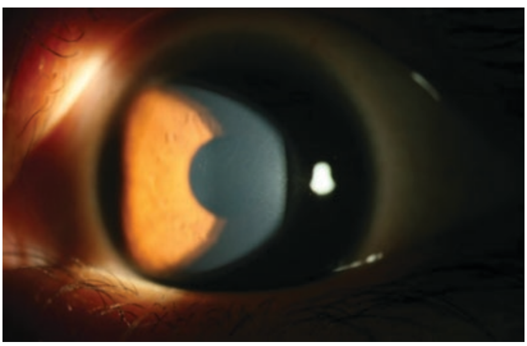

Fig. 15.10 The corneal epithelium recovering smoothness and clarity

15.5.1 Tips and Pearls

This patient was burned by ultraviolet lamplight. Epithelial defects are mainly pathological signs. For the treatment, please see Chap. 3.1 "Corneal Abrasion". The keratitis associated with radiation burns typically heals within 48 h and can be treated symptomatically with topical lubricants. Patients suffering severe symptoms can temporarily wear bandage contact lenses for pain relief.

Treatment of thermal ocular burns at the acute stage is primarily to keep away from the heat, rinse with cold water, and remove the heating foreign body, with principles similar to chemical injury. The common surgical approaches include amniotic membrane transplantation, lamellar keratoplasty, penetrating keratoplasty, corneal limbal stem cell transplantation, and artificial cornea transplantation. For the operation principle, please see Chap. 14 "Ocular Chemical Burns."

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